TENTH BIENNIAL RE

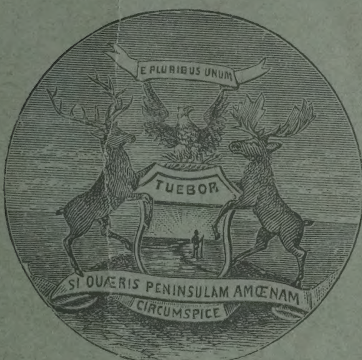
OF THE

STATE BOARD

OF

ISH COMMISSIONERS

FROM OCT 1, 1890, TO DEC. 1, 1892.



BY AUTHORITY

LANSING
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1893

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STATE BOARD OF FISH COMMISSIONERS.

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COMMISSIONERS.

Dr. JOEL C. PARKER, President, - -	Grand Rapids.
HOYT POST, - - - - - -	McGraw Block, Detroit.
HERSCHEL WHITAKER, - - - -	Moffat Block, Detroit.

OFFICERS.

WALTER D. MARKS, Superintendent, - -	Detroit.
GEORGE D. MUSSEY, Secretary, - -	No. 78 Moffat Block, Detroit.
Wm. A. BUTLER, Jr., Treasurer, - -	Mechanics' Bank, Detroit.

OFFICE OF THE BOARD,

NO. 78 MOFFAT BLOCK, DETROIT, MICH.

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REPORT.

To His Excellency, John T. Rich, Governor of the State of Michigan:

In compliance with the requirements of law, the State Board of Fish Commissioners herewith submits its tenth biennial report of operations. The period covered by this report is from October 1, 1890, to December 1, 1892.

When it is remembered that the first successful experiments in the artificial propagation of fish on this continent were made at a time within the recollection of persons now living, the progress that has been made and the results achieved in fish culture seem almost marvelous.

The first experiments were made by naturalists and were upon a very limited scale; but the work was continued and grew from an output of hundreds to thousands and then to millions and hundreds of millions. The original efforts were made from curiosity and the interests of scientific research, but the work has long since advanced beyond the stage of experiment, and has come to be for several years past a matter of state and national interest, receiving the recognition and support of the federal government as well as that of many of the states.

Of all the states of the union none has taken a greater interest in this work, or done more than the State of Michigan towards the successful propagation and distribution of food and game fish, and it is mete that this should be so, for no state is more advantageously located to reap the fullest benefits of such work, with her extended fresh water coast line and her numerous inland lakes and streams.

While much has been done in the State in the way of stocking the streams with game fish from which most satisfactory results have been attained, the work in which the State has outstripped all competitors is in propagating and distributing commercial food fish and especially the whitefish and wall-eyed pike. It is in this class of work particularly that great output with relatively small outlay has been made possible. The invention by one of the former employés of this Board, who sacrificed his life in his devotion to the work, of the Chase hatching jar, has been the means of greatly reducing the cost and labor attending the care and hatching of the eggs of these classes of fish, so that where before thousands could be hatched, now with the same labor and little additional expense the hatch product reaches up into hundreds of millions. Almost the only limitation to the output that is attainable within reasonable bounds of expenditure, is caused by the difficulty in obtaining the eggs. This will be better appreciated when it is stated that it requires nearly a

hundred and thirty bushels of whitefish eggs to fill the present Detroit hatchery, i. e., 1,029 jars of four quarts each. When once the eggs are obtained and fertilized in takes little more labor for the succeeding four months to attend to a thousand jars than it does with only half the number.

The total plants of whitefish made by the State since 1874 reaches the large number of nearly 750,000,000, of which more than one-half have been made within the past five years.

The number planted in 1874 was little above a million and a half, and the twenty million point was not reached until 1883, and the fifty million point until 1886, and the hundred million point until 1890. The present capacity of the Detroit hatchery and the small hatchery at Sault Ste. Marie will nearly reach two hundred million.

Considering that it takes from four to six years for the fry planted in any one year to reach an age of maturity to make any considerable show in the catch, it will be seen that we should naturally expect to be only just beginning to reap the benefit of the great plants that have been made since 1886. Still it is a fact that for more than five years past the fishermen, who at first were inclined to make light of artificial fish culture, have been almost unanimous in the conviction that the work done by this Board in that line has resulted in great benefit to the fishing interests.

It is the subject of congratulation for ourselves and the State that we have at last succeeded in taking and fertilizing sufficient whitefish ova to fill all the jars in both the Detroit and the Sault Ste. Marie hatcheries. Three years ago the Detroit hatchery was doubled in capacity, but owing to storms and other drawbacks, we were unable to obtain sufficient eggs to fill the house either last year or the year before. Last year our capacity for hatching whitefish was increased by the opening of the small station at Sault Ste. Marie, but although every effort and precaution was taken, it was found impossible to obtain eggs enough to fill both houses owing to the prevalence of violent storms in the height of the egg-taking season. This difficulty is one that obtained generally, and we suffered no more relatively than others engaged in the same work.

The white fish hatchery at Detroit is undoubtedly the largest, best arranged, best equipped, most economical and most efficient in the world. No other has begun to compete with it in output, and it is a source of much gratification to us that this season we have succeeded in filling every jar in it with fertilized eggs.

It is a beautiful and inspiring sight to look upon its tiers of jars, more than a thousand in number, all filled and in active operation.

We cordially invite the public generally and all interested in the subject to call and inspect it. It is something that nowhere else can be or ever has been seen, so large a quantity of eggs undergoing the hatching process with so little outlay or trouble. With the labor of but four attendants this work now goes on almost automatically for upwards of four months before the hatching takes place.

The most interesting time to visit the hatchery, however, is in the month of March when the embryo fish is leaving the shell, and when the hatch is at its height the talk of millions and hundreds of millions is best appreciated, for their numbers seem like the leaves of the forest or the sands of the seashore.

If it were possible for all the other states bordering on the great lakes to do relatively what Michigan has been and is doing in this line, and they

were willing to do it, the question of restocking these waters would, with proper legal protection, be solved; but there are many things to be considered. The most difficult part of the problem is to obtain and store the fish in a sufficiently sheltered location to permit of retaining them until they are ready to give up their eggs. The Detroit river is an ideal location for that purpose, when the fish are sufficiently plentiful. But some years the run is light and short and comes in the midst of storms that prevent a sufficiently large catch; while in less sheltered localities storms carry away the nets and render it impossible to hold the fish in the crates after they are caught. In many localities it is impracticable to do anything more than to strip such fish as are ripe when caught, while in the enclosed water of the Detroit river all the fish caught can ordinarily be safely kept alive in crates until the eggs are ready to come. Still even there many difficulties and disappointments beset the work, through ice and storms and changes of temperature, and nothing short of long experience and acquired skill and constant vigilance will insure anything like uniform success even under most advantageous circumstances. When any one exhibits as the result of a season's work upwards of twelve hundred jars of well impregnated whitefish eggs, you may be sure it represents much careful forethought and oversight, constant watchfulness and care, as well as considerable skill and hard and continuous work. It means the capturing and preserving alive and healthful and handling over and over again about twelve thousand fish and so manipulating them as to get all out of them there is in them, without injuring or destroying the fish. It means much patient, persistent and hard, cold and disagreeable work, as well as much practical skill.

It is within the range of possibilities to make every acre of water more productive of suitable and healthful food for the human race than any acre of fertile dry land. Think for a moment what this means to a State situated as Michigan is! We hope the time will come when it will be thought extravagant and wasteful, and be made unlawful, to kill any valuable commercial food fish during the spawning season, until after it shall have given up its eggs to be fertilized and hatched to take its place in replenishing the waters from which it was caught. If all the eggs of all the fish taken during the spawning season were impregnated and hatched, and restored to the waters, and at the same time the culpable and wanton destruction of half grown and immature fish were stopped, within a few years the waters would teem as of old with abundant supplies of all kinds of valuable fish.

Hand in hand with the restocking of waters must go the prevention of the wasteful capture of immature fish, or the work is almost as bad as thrown away. The State cannot afford to hatch and plant fish fry to have them seized by greedy fishermen before they have half attained their growth, and when they are almost worthless for food. The only way to reap the full benefit of the work of fish culture is to prevent the taking or marketing of the fish until they have reached a reasonable maturity.

No valuable food fish ought to be allowed to be taken, killed, or sold on the market until after it has reached an age to have cast its first crop of eggs—which means a growth of from three to five years.

We believe it is becoming to be the opinion of a vast majority of the commercial fishermen that adequate and suitable laws should be enacted and enforced for the protection and maintenance of the whitefishing industry; that these laws should be such as to disturb as little as possible and

interfere in the smallest degree with the nets and fishing outfits of the smaller fishermen whose entire capital is very likely to be invested in the single net and outfit that he owns.

The fishermen generally seem to be of the opinion that this would best be accomplished by a law fixing the size of the whitefish that might be lawfully taken from the waters and sold in our markets, and providing for the confiscation of all whitefish of smaller than the lawful size wherever found; whether in the possession of the fisherman or of the dealer. This matter may be worthy of careful consideration for there is no doubt that any protective measure that has the cordial support of the fishermen will be more easy of enforcement than those that meet their hearty disapproval.

The question of a close season for whitefish has been much considered and is a very difficult one owing to the difference of dates of the spawning season in different localities. There can be no question that a thirty or even a twenty days' close season, at the proper time, would be of great benefit, and would add largely to the success of the work done by this Board, and the Board leave the question with the hope that all legislation looking to the protection of whitefish shall be intelligent and conservative, but of a character that will produce the result desired with as little annoyance, inconvenience and loss to those engaged in the business as is consistent with the thorough and effective protection of this most valuable food fish.

The work of the Board for the two years embraced in this report has been eminently satisfactory when all things are considered. The output of all fish except whitefish has been larger than in any previous two years, and the output of whitefish was about the same as for the two years next preceding, and greater than for any two years previous to that; and the relative falling off was less than in any other state in which whitefish are extensively propagated.

The evidences of the success of all fish propagating efforts are more marked and more generally satisfactory than ever before. A large number of gratifying reports of the success of the brook trout work have been received, and the enthusiasm expressed by those from whom letters have been received has never been equalled.

The State has been transformed from a land barren from this beautiful fish to one in which good trout fishing is abundant, and a reputation for the State in this regard has been firmly and widely established.

Besides bringing the State into the front rank as a field for trout fishing for sport, which attracts thousands of tourists every season within its borders, the results of trout work have been to add many dollars worth of the finest food to the supplies of the farmers and others living in the vicinity of the trout streams.

Indeed the firmest friends the Board and its work has today are numbered among the farmers and others whose homes are near the brooks and streams where the trout flourish best, and they are the ones most benefited by this work, and they appreciate the fact.

There are hundreds of such streams in the State which may be said to almost teem with brook trout, as a direct result of the systematic, persistent and intelligent work of this Board.

The results of brook trout planting in streams are so open to inspection and so easily observed and appreciated that it is not difficult to convince any caviller of its benefits by actual demonstration and proofs that cannot

be gainsaid, while with the commercial fish that inhabit only the wider and deeper waters, it is not so easy, in the nature of things, to bring absolute proofs, yet it stands to reason that if the relatively smaller output of brook trout can have produced such satisfactory results, the millions upon millions of whitefish and wall-eyed pike must have made a marked impression on the commercial fisheries.

But the commercial fishes have never had half a chance. The appliances for catching these fish have been so improved, and the fishermen are so eager to take and sell all that comes to their nets, that but few of the fry planted are allowed to reach anything like maturity. There are over two thousand miles of nets fished in Michigan waters alone, and nearly all of them send immature whitefish to the market. Yet notwithstanding this, and the disposition of fishermen formerly to poke fun at scientific experiment, the increase of fish from artificial propagation has become so manifest, and has so impressed them, that it is the rare exception now that a fisherman can be found to decry the great work. The evidences increase every year, and the witnesses are volunteering their testimony, while the opposition that once was so vigorous and persistent has almost entirely died out.

MEETINGS OF THE BOARD.

Meetings of the Board are held monthly, generally at the office of the Board in Detroit, but occasionally as the demands of the work requires meetings are held at the Paris station and elsewhere as is most convenient for the consideration of the matters in hand at the time. At each meeting reports of the work done and progress made at the different stations during the past month and the requirements for the future are submitted and considered. These meetings are nearly always attended by the full Board, the secretary and superintendent, unless unavoidably kept away. Full records are kept in substantial books of all the transactions of these meetings for future reference and inspection.

Two members of the Board act as an auditory committee to approve all accounts and bills before payment. This committee for the past two years consisted of Mr. Whitaker and Mr. Post. All bills are in duplicate and must be O. K'd by the employé in charge of the work. The Board has since its last report inaugurated the plan of making all payments by check to the order of the claimant, which are signed by the secretary and the member of the auditing committee who passes on the bill. Receipted vouchers are required of all disbursements exceeding one dollar of a character where such vouchers are reasonably obtainable. Requisitions are required of all purchases of any consequence, to be approved by the member of the Board in charge of the work.

The supervision of the different branches of the work is allotted among the commissioners for the purpose of distributing the responsibility and dividing the labor among the members. This is usually done at the June meeting, but at the last June meeting no change of distribution was made. For the past two years the trout station at Paris has been in charge of Dr. Parker, the whitefish stations at Detroit and Sault Ste. Marie in charge of Mr. Whitaker except that during this last fall Mr. Post has aided in the work of the Detroit station, and the carp station at Glenwood and examination of waters and propagation of new species have been in charge of Mr. Post.

Meetings were held on the dates and at the places specified below, viz:

In 1891. At Detroit, January 30, February 27, March 27; Paris, May, 2; Detroit, June 26, July 31, August 28, September 25, October 30, November 27 and at Grand Rapids, December 30.

In 1892. At Detroit January 29, February 26, March 18, 26, 30; Grand Rapids, April 1; Detroit, April 29; Paris, May 16; Detroit, June 3 and 11; Grand Rapids, July 26; Detroit August 26, October 7, November 4 and 25.

SAULT STE. MARIE STATION.

The last Legislature having voted a small appropriation to maintain a whitefish hatchery on the Upper Peninsula, at Sault Ste. Marie, the Board visited that place in the summer of 1891 and prevailed upon the city to grant us the free use of water from the city water supply and to donate the use of a small store building for the period of two years ending August 1, 1893. It became necessary for us to ask this, since no appropriation was made beyond the amount required to equip and run the hatchery on the most economical basis. It was regarded and intended as an experiment only, to conclusively determine what the Board had long believed in, the advantages of a hatchery on the Upper Peninsula for hatching whitefish for planting in Lake Superior and vicinity. The experiment has corroborated the views of the Board as to the utility and necessity of such a hatchery. The effort to plant fry in Lake Superior which were hatched in the Detroit house had proved disappointing and fruitless because owing to the higher temperature of the water at Detroit, the hatch came on and was over before the ice in Lake Superior was out of the harbors and tugs could not be had to go out with the fry to the spawning beds where the plants are required to be made. The difference in temperature of the water used at the Sault was such as to retard the hatch about three weeks, which enabled us to plant the fry where they belonged.

A small hatchery containing about 200 Chase jars for hatching whitefish and such troughs for the hatching of salmon trout and brook trout as the space in the building afforded was set up and equipped in the building donated by the city, ready for use in the fall and winter of 1891. As was feared, much difficulty was experienced in obtaining sufficient whitefish ova to fill the jars. Every reasonable effort was made. In addition to making such provisions as opportunity afforded in the immediate vicinity, nets were purchased and set in Torch Lake and in that neighborhood, and the fisheries on Traverse bay were visited, but the season was not propitious, and the violent autumn storms prevented the taking of eggs enough to fill the jars, nor did we succeed in obtaining eggs enough that season at Detroit to fill the jars in the Detroit house. However the eggs which were taken and placed in the jars at the Sault station were hardy and in good condition and hatched out strong and vigorous fry. The temperature and condition of water there is all that can be desired for hatching either the whitefish or brook trout.

It is deemed desirable to continue the experiment for two years longer, but to do so it will probably be necessary for the State to pay the rental of the store at least, if not for the use of the water. The State cannot reasonably ask of this community, whose means are small, that it shall bear so large a share of what ought to be a common burden. During the coming two years the Board expect to make further investigations so as

to be prepared, if everything remains favorable two years hence, to recommend a location and an appropriation for a permanent hatchery somewhere on the Upper Peninsula, which shall be on a scale suitable to the work required, and include an equipment for hatching both whitefish and trout, and ponds for holding the necessary stock fish. This we are not prepared at present to do.

The whitefish eggs which were put into this hatchery last year came partly from Tahquamenaw bay, partly from Torch lake and partly from the north shore of Lake Michigan and in the neighborhood of Detour. The salmon trout eggs were mostly taken from the neighborhood of Detour.

There were brought to this station in 1891 one hundred and fifty thousand brook trout eggs from Paris, of which 135,000 were hatched and planted.

An interesting experiment was made at this station with salmon trout eggs in a jar, the report of which by W. D. Sargeant, overseer, is as follows:

"In regard to the experiment of running salmon trout eggs in a jar, on November 24, after being on trays twenty-five days, I placed in a jar five quarts of salmon trout eggs. I also on the same date placed the same number of salmon trout eggs on trays. After placing eggs in jar I found that the ordinary fall of twenty-two inches from faucet to bottom of jar with faucet wide open was not of sufficient force to keep the eggs moving properly, so I connected the tube with the upper feed tank, getting a fall of five feet from faucet to bottom of jar. The jar in this position required seven quarts per minute to run it, while it takes but four quarts per minute to run a jar of whitefish, and twenty quarts per minute to run a trough containing 200,000 salmon trout eggs. I had no trouble with the eggs in jar in any way, and the "ringers" as they would break would have no effect whatever on the other eggs, and I would have to siphon the bad eggs off but about once in two weeks. On March 15, after the eggs had been run in jar 112 days, I took them out, as they had commenced to hatch, and placed them on trays, and found there had been a loss in the jar of 23 ounces, or 14$\frac{3}{8}$ per cent, while the corresponding number of eggs on trays had lost 32 ounces or 20 per cent up to the same date."

The number of salmon trout eggs put in this hatchery last year was 300,000 of which 230,000 were hatched and planted. The first take of eggs was on October 20 and the last on October 28. The first hatch February 24, and the last May 12.

The number of whitefish eggs put in this hatchery in 1891 was 12,004,800 of which 9,724,000 were hatched or a loss of 19 per cent.

The first take of eggs was November 5, the last December 2. The first hatch in April and the last May 15.

The temperature of the water began November 15 at 42 and for the month ensuing varied from 42 to 38, and about January 1 ran down to 34 where it remained without variation to exceed one degree either way until April 20, and from then till May 15 it did not go above 40.

DETROIT STATION.

Since the enlargement of this station in the summer and fall of 1889, very little in the way of outlay for permanent alteration or considerable

repairs has been necessary. The changes then made were so satisfactory and complete and the work so well done that much in the way of additions has not been required. The necessary repairs to keep the property in first rate condition have been made as needed. Something of this nature is required every year. The present season some repairs have been necessary on the troughs. Some of which have been in use for some time and had become somewhat decayed.

The ground lease of the premises on which the Detroit station is located expires July 1, 1893. As it was necessary before the lease expired to ascertain what would be done about an extension of the lease or to cast about for a new location, the board interviewed the lessor, Mr. John Pridgeon, Jr., on the subject. The present lease was for ten years and was at a rental of two hundred dollars a year. On July 14, 1892, a new lease was made for a term of ten years from July 1, 1893, at an annual rental of five hundred dollars, payable quarterly, with the right to surrender the premises July 1, 1895, 1897, 1899 or 1901, on giving the lessor two months notice in advance. This increase in rent is not more than was warranted by the increase in value of the land during the ten years since the present lease was made, and was considered by the board as a very fair rental, and much more profitable than to attempt now to move to a new location, even though a better one, as this involved a considerable additional expense in building and equipping a new house or moving the old one. By the time this new lease expires the building will be about twenty years old and a removal will not be at so much of a sacrifice in value in that respect.

It is manifest to the Board now that it would have been good economy in the first instance to have made a little larger outlay and purchased a location, instead of renting. The present location and the present building and equipments, with the expenditure of enough to keep it in good repair, will probably answer all requirements for the coming ten years.

There were put into this station in the fall of 1890, 111,564,750 whitefish eggs, of which over 92 per cent, or 104,000,000, were hatched and planted. The first eggs were taken November 6 and the last December 11. The date of the first plant was March 30, 1891, and of the last April 30. The table of plants in the appendix shows the location and date of the several plants with the amounts planted in each locality.

In addition to this in the spring of 1891 there were hatched in this station 27,045,000 wall-eyed pike. These were all planted between May 12 and 25. The table of plants in the appendix shows date, amount and place of each plant and to whom delivered.

In the fall of 1891 the number of whitefish eggs taken and planted in this hatchery was 73,858,800, of which 65,500,000 were hatched and planted. The first hatch being on March 2, 1892, and the last on April 20. The first plant was on March 19 and the last on April 23. The table of plants in the appendix shows date, amount and place of each plant.

In the spring of 1892 there was hatched from this station 57,300,000 wall-eyed pike which were planted between May 25 and June 12. The table of plants shows the date, amount and place of each plant.

PARIS STATION.

The repairs to this station during the past two years have not been great, owing to the satisfactory condition in which everything has remained

since our last report. No additions or considerable repairs have been required on the hatchery. The building was so well designed to meet not only the then present needs but also the demands of the immediate future, that no increase or alterations of any considerable amount have been needed and only ordinary repairs have been expended upon it. It is as commodious and convenient a building for the purposes for which it was designed as exists anywhere.

In the latter part of March, 1891, a flood occurred on Cheney creek, which washed down about thirty rods of the stone wall of the waste ditch, and also washed out a large hole at the foot of the waste ditch and the bottom of the large race that runs under the railroad. During the summer these injuries were repaired and the race under the railroad was rebuilt and extended to the dam below the railroad and a large new pond was built south of the race, and the ground and banks about this pond and extending up the bluff was graded and sodded. In repairing the waste ditch the walls were lowered and the banks rounded down to the top of the walls and sodded, which much improved its appearance. Ponds numbered 8, 10, 11, 12 and 14 were rebuilt and improved by removing the bulk heads between each spawning and gravel pond and making provision for dividing them by a long screen during the spawning season so arranged that it could be moved at other times. The plank walls were removed and sloping walls of small cobble stone substituted, and the banks were lowered and rounded down to the water's edge and sodded. The same repairs were also made on the wild pond by the wagon road, and the corners were also rounded. These improvements add to the tasteful appearance of the ponds and the stone walls are found to be both better and more permanent.

There was no adequate provision made in the new hatchery for office room, the office having before been kept in the wing of the old hatchery. This necessitated a good deal of going back and forth, and a consequent waste of time, and to obviate this an office and sleeping room were combined and the space under the stairway utilized. This makes a very convenient office and affords a sleeping place for the person in charge, which at times saves the expense of a watchman.

A large new refrigerator for the meat house and a new floor were also built. Other improvements and repairs consisted of painting the windmill and water tank, and building a register on the water tank. The car house was also battened and painted, and a boom was placed across the inlet to the ponds to carry off by the waste ditch the floating scum and dirt that was brought down by the current.

An opportunity came to the Board to exchange some of its cleared land adjoining the station, and which did not border on the streams, for a forty acre lot through which Buckhorn creek runs, and which it was desirable for the commission to own for the purpose of controlling and protecting the waters of the creek. The forty acres belonged to John H. Westerman, and is described as the southwest quarter of the northeast quarter of section nine (9) in town sixteen (16) north of range ten (10) west.

The parcel given in exchange for it is described as commencing at a point on the section line between sections nine (9) and ten (10) in said township, forty-six rods north of the quarter post, and running thence south, seventy-five (75) degrees east, thirty-five (35) rods and ten (10) links to the railroad right of way; thence northerly along the west side of said right of way to the section line; thence west on the section line to the corner of sections three (3), four (4), nine (9), and ten (10), and

thence south on the section line to the place of beginning. The exchange was made July 29, 1892, and besides the land Mr. Westerman was paid two hundred dollars. The exchange was regarded by the Board as an advantageous one for its purpose, and at the same time was a fair one to Mr. Westerman. Before making the deal the members of the Board went over the ground and procured the aid of the county surveyor to fix the lines and give the description of the parcel conveyed to Mr. Westerman.

December 15, 1891, there were shipped to the Sault hatchery 200 new egg trays made at the Paris station, and on January 28, 1892, 55 more.

December 25, 1891, there were shipped to the Sault hatchery 150,000 brook trout eggs in good condition.

January 12, 1892, the stand pipe under the water tank froze and it became necessary to put a stove in there and to keep up a fire on all very cold days. During the season of 1892 a wild race was put into the Buckhorn and another in Cheney creek and also two pockets near the mouth of the latter.

The first brook trout eggs for the season of 1890-1 were taken September 29, 1890, being seven days earlier than in 1888, and six days earlier than in 1889. The last were taken December 12, being seventeen days earlier than the close of the season of 1888, and twelve days earlier than in 1889. The total number of brook trout eggs taken this season was 2,836,000, and in taking and fertilizing the same 4,283 females were handled and 2,685 males, being an average of 663 eggs per female. The first were hatched December 8, 1890, and the last March 18, 1891; the hatching period covering a total of ninety-one days.

Of the eggs taken 2,500,000 were hatched and distributed, showing a loss in hatching of a trifle over twelve per cent. The brook trout fry hatched were distributed and planted in 404 streams in fifty-eight different counties.

Brook trout have now been planted in all the counties of the lower peninsula except six, viz.: Bay, Benzie, Huron, Missaukee, Sanilac and Wayne, and have been planted in three counties of the upper peninsula.

In the season of 1890-1 there were taken 169,500 brown trout eggs, of which 156,000 were hatched and planted, showing a loss in hatching of 13,500 or 8.14 per cent. The brown trout fry were distributed in thirteen streams in nine counties.

During the fall of 1890 there were caught with a seine in the Buckhorn and Cheney creeks 2,186 spawners, 2,171 yearlings and 743 babies, all brook trout, and 743 brown trout, making a total of 5,826 fish. The number of stock fish was 7,276 brook trout and 1,800 brown trout.

In the season of 1891-2 the first brook trout eggs were taken September 26, 1891 and the last January 5, 1892, and the first brown trout eggs were taken October 14 and the last December 10, 1891. The whole number of brook trout eggs taken was 2,702,000. The first hatch was December 17, 1891, and the last April 15, 1892. Total hatched 2,500,000, total planted 2,413,000. The first plant was February 8 and the last April 28, 1892.

The whole number of brown trout eggs taken was 287,000, of which 275,000 were hatched and 271,500 planted. The first hatch was January 25 and the last March 24, 1892. The first plant was made March 4 and the last April 15, 1892.

In the fall of 1892 there were caught from the creeks 1,800 wild brook trout. The number of stock fish was 7,800 brook trout and 1,800 brown trout.

SPAWN GATHERING.

WHITEFISH.

The ova of the whitefish for the Detroit station has been taken principally from the fisheries on the American side of the Detroit river. For the last two years we have handled all the fish taken on this side of the river, and in order to obtain what we required have been obliged to look after the fisheries pretty sharp at times. We have finally arranged to control all these fisheries ourselves, and the past season have hired the fishermen out and out and managed the fishing directly, owning and selling the fish caught.

The catch of 1890 in the river was somewhat smaller than in former years, a portion of the fisheries were not run at all, including Craig's and East point and several others, viz: Belle Isle, Red Shanty, Mama Juda and the Stock Farm were not well fished. Mama Juda, Stock Farm and Red Shanty were abandoned early in the season because the fish did not show up well, though it is likely if they had been continued some whitefish might have been caught. It has always been a difficult thing to control the fishermen who conducted the fisheries. At Fort Wayne great trouble was experienced in the early part of the season from sunken logs and obstructions on the fishing grounds on which the nets caught and were torn, letting the fish escape. After the grounds were well cleared a reasonable number of fish were caught. A much larger proportion than usual of small males were taken, some very large males were also caught and the females were about the usual size taken in former years. The fine condition of the fish taken was noticeable, and the eggs secured were very fine. The whitefish came on very late and the run continued later than usual. This leads to the opinion that if the fisheries which were abandoned early had been continued better success would have resulted.

No herring of any consequence have been taken on the river for the past three years, which seems very remarkable considering the large quantities that have formerly been caught here even at a quite recent date.

The small tug or steam yacht "May H." was chartered for the season of whitefish taking, at the rate of seven dollars a day, the owner furnishing his own crew and fuel. The arrangement proved very satisfactory and the yacht was found a great aid in the work; she was again employed at the same rate in the fall of 1891, and in the season of 1892 another boat of like character was engaged in her place. The work has become so extensive and the fisheries are so far apart that it has become a matter of absolute necessity, as well as economy to have the use of such a steamer during the spawn taking season.

The first whitefish eggs were taken in the season of 1890 on November 6 and they were taken on that date at every fishery on the river. The last eggs were taken December 11. The cold weather coming on suddenly about 250 fish were frozen in at Grassy Island, remaining there till January 7, 1891, and we were unable to get our crates out of the water.

Two quarts of whitefish eggs were shipped to Prof. Jacob Reighard at the university at Ann Arbor for scientific investigation and experiment.

On October 20, 1890, the superintendent went from Paris to Sault Ste. Marie to take whitefish eggs, and spent all his time until November 16 in the search, going to every available point from the Sault. On account

of the scarcity of the whitefish it was impossible to secure a large number of eggs. He succeeded, however, in getting 6,794,000 first-class eggs, which were shipped to Detroit, and placed in the jars in fine condition.

The number of whitefish eggs put into the hatchery was 120,288,750; and on January 16 a measurement was taken to determine the loss in working off bad eggs and it was found there were left 111,564,750, or a loss of a little over seven per cent; indicating that the eggs were of the finest quality and had been well handled.

The fisheries from which the fish were handled in the fall of 1890 were the following: Belle Isle, Craig's, Fort Wayne, Grassy Island, Mama Juda, Stock Farm and Red Shanty. The whole number of females crated was 3,131, of which 2,119 were stripped. The whole number of males crated was 5,577, of which 4,589 were stripped. The reason of the discrepancy between those taken and those stripped is that of about 2,000 fish bought from Labadie and Reaume none were stripped because the females were spent before they were received.

For the season of 1891-2 preparations for whitefish spawn gathering commenced about October 15. The first whitefish were caught at Grassy Island October 20. At Fort Wayne fishery the fishing was commenced October 29 and the first catch October 30. At Stony Island the first catch was November 5, and at Belle Isle on October 31. The fishery on East point at Belle Isle, near the lighthouse, was fished this season for the first time in several years. The fish caught here were crated at the Willis fishery on Belle Isle. On account of the low water, only 138 fish were caught at the Stony Island fishery, and work there was abandoned November 13. On November 18 Mr. Dwight Lydell was sent to Point Mouille for eggs, but found that the whitefish had about quit running and that the fishermen were taking up their nets; he got only five quarts of eggs there.

All fishing on the river ceased this year on November 27. No fishing was done at Red Shanty, Stock Farm or Craig's this season, and the East Point fishery was abandoned in the height of fishiug on account of heavy winds and cold weather, the men refusing to go out. The heavy wind and roily water also prevented the usual catch at the Fort Wayne fishery. Herring fishing was almost a failure this season, the total catch not exceeding 20,000.

The total catch of whitefish at the different fisheries was as follows: Belle Isle 1,003 females, 2,275 males; Fort Wayne 347 females, 1,241 males; Grassy Island 644 females, 1,223 males; Mama Juda 543 females, 943 males; Stony Island 80 females, 58 males; total 2,607 females and 5,740 males, of which there were stripped 2,203 females and 4,021 males. The egg taking continued until December 10, and the eggs taken were in fine condition. The whole number of crates used was 50, of which 12 belonged to the U. S. fish commission. The whole number of eggs taken was 73,858,800.

The fisheries at Mama Juda and Grassy Island were operated by Messrs. Schufert and Cahalan under a lease from the United States, and the whitefish were handled by this commission by virtue of a condition in their lease reserving to us the right to handle all fish taken. This arrangement did not work satisfactorily to either. They were paying too high rent for the fishing privilege to be able to make any profit. The outcome of it all was that our board bought them out, both their lease and their fishing outfits, and then arranged with the government to remit the rent.

It has not been usual to include the work of the current season in spawn gathering in the reports, but as the preparation of this report has from unavoidable causes been delayed until the work has been completed for the season, and as there has been a change of plan in the matter of dealing with the fisheries on the river, it is thought desirable to relate it. The board has been from year to year acquiring more complete control over the fisheries of the river, as it became more and more necessary in order to obtain the requisite quantity of white fish ova, and has had more or less embarrassment growing out of the inefficiency and lack of push of those who engaged in the business of conducting these fisheries; it was therefore this season decided to hire men to do the fishing under the management and control of the board.

This insured complete ownership by the board of the fish, the sale of which it was expected would go a good way toward recompensing them for the increased expenditures. This necessitated an outlay for seines, boats and outfit, and put upon the board the risk of the financial success of the venture. A portion of the equipment and outfit had been accumulated before, as had become necessary in order to have the grounds fished. It greatly increased the labor and responsibility of the superintendent and the risks of the work, but it insured the right to control and direct when, where and how the fishing should be done. It required the hiring and subsistence for from forty to sixty days of about fifty men and ten horses and the use of a small steamer. The board controls eight fisheries, but only five were worked, viz.: East Point and Willis fisheries on Belle Isle, and the Fort Wayne, Grassy Island and Mama Juda fisheries below the city.

The work of repairing the outfit, boats, nets, docks, platforms and grounds began as early as October 3. One new seine was bought and six old ones repaired. At the fisheries on Belle Isle the platforms, spiles and everything are required to be removed at the end of each fishing season and replaced before the fishing commences. The steam tug or yacht "Bertie E" was chartered at seven dollars per day, commencing October 11. The crates had been stored at or near the Fort grounds and at Grassy Island and had to be repaired and removed and put in place at the different fisheries.

The fishing commenced at the Belle Isle fisheries on October 20, at Fort Wayne on October 24, and at Grassy Island and Mama Juda October 25. The early fishing at East Point was much interferred with by obstructions on which the nets caught and were torn and the same thing occurred somewhat at the other grounds. The fish taken at East Point were crated at the Willis fishery, and those taken at Mama Juda were handled at Grassy Island. At Mama Juda no fish were caught till October 27 and the fishing continued there eighteen days till November 13, the catch being 854 or 315 females and 539 males. On November 15 this crew was taken to the Willis fishery to fish as second crew. The number of fish caught at Fort Wayne was 2,001, or 815 females and 1,186 males. Of these, by the terms of our lease, 500 were given as rent to the post at the Fort. The fishing was carried on here 36 days and two nights, and 294 hauls of the seine were made, the catch averaging about seven fish to the haul.

At East Point the fishing continued 21 days and two nights, the largest catch in one day being 387. The heavy wind interfered with the fishing here at the height of the run, as the ground is more exposed than at other fisheries. The night catch here did not amount to anything. Altogether

1,486 fish were caught here. At the Willis grounds the fishing lasted 35 days and ten nights, two crews fishing 24 hours a day during those ten days and nights. The best run on these grounds was between midnight and morning. The number of fish caught here was 5,636, making a total caught at the two Belle Isle fisheries of 7,822. The number of males stripped here was 3,011 and females 4,001. After the fishing ceased on November 24, a night watch was established and continued till the egg taking ceased and the fish were sold.

At Grassy Island the fishing lasted 36 days and two nights, none were caught of any consequence at night. The largest day's catch was 235 on November 14. The good fishing lasted only about one week. The catch here was 3,152, or 1,618 females and 1,534 males. There were stripped 1,618 females and 1,489 males. The eggs from here were shipped to the hatchery at Detroit in whitefish cans, in water, about 20 quarts to a can. They carried well.

The total number of fish caught at all the five river fisheries was 13,074. The total eggs taken from these fish was 4,744 quarts or 142 bushels, making 173,630,400 eggs. Of these 625 quarts were packed in boxes and forwarded to the hatchery at Sault Ste. Marie. There were also taken at the fisheries on Lake Superior eggs enough to fill 43 jars, equals 172 quarts, which were also placed in the Sault hatchery.

This is a larger catch of fish than has been taken at these fisheries on Detroit river in years, and it was accomplished by persistent and intelligent work, still it is certain that the proceeds ot the sales of the fish will not reimburse the Board for the money expended, and if the fishing had been done by those who were in it only for the money they could get for the fish they would have quit as soon as the heavy run ceased, and we should not have obtained the quantity of eggs we did. On the whole we are very well satisfied with the policy of doing our own fishing.

WALL-EYED PIKE.

In the season of 1891 Mr. Orr D. Marks, overseer of the Paris station, went on April 8 to Bay City to gather wall-eyed pike eggs at the mouths of the Kawkawlin and Saginaw rivers. He arranged to take the hard and unripe fish and crate them in the rivers. The fish were taken from nets about two miles out in Saginaw bay and transported in wash tubs to the crates, which were located in sheltered places near the mouth of the rivers. There were crated in this way in Kawkawlin river 290 females and 98 males, and in Saginaw river 281 females and 99 males. Arrangements were also made with fishermen who were fishing off the beach to hold their fish till ripe in nets, but the storms chafed holes in the nets and all the fish in them were lost. The eggs of the fish that were ripe when caught were taken at the nets.

The first eggs were taken April 11 and the last on April 24. There were taken in all 64,531,400, and hatched and planted 27,045,000. They were in the jars 26 days before hatching. There were handled the fish caught from eight strings of nets (30 pound nets) and eight men were employed in the work for the Board.

In the season of 1892, Mr. Orr D. Marks went about April 12 to Bay City to look after the wall-eyed pike work. He had considerable difficulty in making satisfactory arrangements with the fishermen, who at first refused even to let a man go in the boat with them to take the eggs from

the fish as they came from the nets, and were unwilling to allow the fish to be crated except at exorbitant rates. He finally succeeded in getting some privileges from some of the fishermen. He handled fish from eight strings of nets (32 pound nets) and gathered about 28,164,000 eggs. The catch was very light and the fishermen began taking out their nets about April 30. The winds were heavy and the waters roily and the fish kept off the shore.

On May 3 he went to Robert's Landing on St. Clair river, where the fish were caught in seines and crated. There was an extra good run of fish and they took 194,020,000 eggs.

The number of eggs taken was greater than in any other season, but the loss in hatching and after hatching was also unprecedented. For some reason, perhaps roily water and high temperature, the eggs fungused badly and many were destroyed, and the fry when hatched were many of them weak and soon died, and besides we had the misfortune to lose 4,000,000 on the car in transportation; so that while we took 222,184,000 eggs, we hatched only 81,780,000 and planted only 57,300,000.

The Saginaw bay eggs were put in the jars April 18 to 29 and were hatched May 13 to 19; the eggs taken on St. Clair river were put in the jars May 4 to 23, and hatched May 24 to June 7. The first plant was May 25 and the last June 12.

INTERNATIONAL FISH CONFERENCE.

Growing out of a suggestion made by A. D. Stewart, secretary of the Ontario Board of Game and Fish Commissioners a meeting was held October 12, 1891 at the Fifth Avenue Hotel in New York City of the fish commissioners of Ontario, New York and Pennsylvania, with a representative of the United States Fish Commission and some others especially interested in fish and game culture and protection. The object of the meeting as stated by its chairman, Hon. Robert B. Roosevelt of New York, was: "Protection, preservation and propagation of food fish in the great lakes." None of the members of our board were able to attend this meeting, but a committee was appointed at this meeting to meet at Rochester, N. Y., on November 10, 1891, to consider and formulate a report to be made to a later meeting to be called by the chairman, with power to add to their number; and an invitation to attend having been extended to the members of our board, Mr. Post attended the meeting at Rochester. This committee meeting was presided over by General Richard U. Sherman, of New Hartford, New York. There were present commissioners from Ontario, New York, Pennsylvania and Michigan, and representatives of the United States commission and others, prominent among whom were Judge George F. Danforth, State Senator Donald McNaughton and Frank J. Amsden of the Cheap Food Fish Association of New York, and representatives of the Anglers' Association of St. Lawrence River.

The matters considered by this committee related to the restocking of Lake Ontario with whitefish and the enactment of uniform laws and regulations by all the states bordering on the great lakes, and Canada, for the protection of fish and game. Incidentally there also came up for discussion a resolution upon the advisability of turning over the main work of the state commissioners to the United States commission. On this latter subject a very strong resolution was adopted expressing decided disapproval of any movement looking towards turning over to the United States

government the work of the state commissions in propagating and planting commercial fish in the great lakes; that the jurisdiction over the fisheries within the boundaries of the state belongs naturally to the state, whose interest in their success is paramount to that of the United States as a whole; and that there is abundant field for the concurrent action of the bordering states and of the general government, and that anything which would detract from the state's interest in this matter will be detrimental to the end aimed at, of restocking the waters of the great lakes. A resolution was also carried recommending the adoption of laws forbidding the taking or having in possession of salmon trout and whitefish of less weight than two pounds each, or bass of less than one pound, or blue pike of less than three-quarters of a pound; also recommending to congress the importance of authorizing and directing a full and careful biological survey of the great lakes under the supervision of the United States fish commission; also recommending that each member of the committee take the text of the game and fish code prepared by the New York commissioners and indicate thereon what provisions would be acceptable to them and what changes they would advise, and report the same at the final meeting of the conference.

On December 8, 1891 a further meeting of said conference was held at Hamilton, Ontario, at which Mr. Whitaker was present. Of this meeting Senator McNaughton was made chairman. The report of the committee which met at Rochester stated that they had not deemed it practical to fix on such provisions in detail as would be requisite to form a uniform code applicable to both countries; that special needs depending upon geographical conditions, on climate, on different prevailing modes of legislation and of administering laws, forbid such uniformity, but that approximation in general features and leading measures may be made to go far towards the attainment of the practical ends desired; they recommend, as the two leading measures necessary, protection and multiplication, and to make these effective, concert and harmony of action between all the government authorities interested; they also recommend the prohibition of net fishing within a mile of the shore line and the requirement that all pound and gill nets set outside this limit be not less than 3½ inches stretch, and that the sale or possession of any fish of less than specified weights be made illegal, viz.: Salmon trout and whitefish two pounds, bass one pound, blue pike three-fourths of a pound, and that artificial propagation to the largest available extent be established and prosecuted. They recommended the system of protection in vogue in New York, which, in brief, is a distinct protection department, acting by itself and within itself, its members holding office only by good conduct, and having a head to direct and a working force at all times prepared for duty, properly compensated by the state for services and expenses, and with the constant duty of watching for and preventing violations and conducting prosecutions.

The resolutions adopted at the Rochester meeting were also adopted by the conference, except one to which the following addition was made, on motion of Mr. Whitaker, and then adopted as amended, viz.:

"*Resolved*, That the United States commissioner be requested to urge upon congress the necessity of granting an appropriation to permit the detail of a force of competent and skilled persons to ascertain and mark in detail upon suitable charts for public use and distribution, the location of the spawning beds of the whitefish, salmon trout and other commercial fish in the great lakes, whereon the fry of these fish artificially propagated may be placed where the fish naturally cast their ova."

This meeting adjourned to meet in Detroit on the first Tuesday of October, 1892, but when the time came, a postponement until after election was deemed desirable.

The final meeting was held at the Cadillac hotel in Detroit, Michigan, on December 20 and 21. There were present at this meeting, among others, Samuel Wilmot, of Ottawa, Canada, Superintendent of Fish Culture of the Department of Marine and Fisheries of the Dominion of Canada, Edward Harris of Toronto, Ontario, Thomas Marks of Port Arthur, Ontario, W. B. Wells of Chatham, Ontario, of the Ontario Game and Fish Commission, L. D. Huntington, William H. Bowman and Edward P. Doyle of the New York Fish Commission, C. V. Osborne, of the Ohio Fish Commission, W. P. Andrus and Robert O. Sweeney of the Minnesota Fish Commission, E. W. Gould of Searsport, Maine, Commissioner of Sea and Shore Fisheries, Frank N. Clark of Northville, Michigan, of the U. S. Fish Commission, Frank J. Amsden, of Rochester, N. Y., of the Cheaper Food Fish Association, and Herschel Whitaker, Joel C. Parker and Hoyt Post, of the Michigan Fish Commission, Charles S. Hampton, Michigan Game and Fish Warden, C. M. Keyes of Sandusky Salt Fish Co., A. G. McDonald of Buffalo Fish Co., James Craig, William Craig, A. Soloman, John J. Speed, William Dupont, L. C. Hough, W. W. Griffin, John Zimmerman, Otto H. Rusch, C. H. Moore, George C. Green and S. R. Kingsley. Mr. Whitaker was made chairman of the meeting, and Mr. Amsden secretary.

The following resolution moved by Mr. Post was carried unanimously, viz.:

"*Resolved*, That it is the sense of this conference that the necessity exists for an efficient and uniform system of protective laws, by a paid Fish and Game Department, on the general basis of the New York laws."

On motion of Mr. Gould the following were unanimously carried, viz.:

"WHEREAS, The different State Fish and Game Commissioners are more in touch with the laws and their defects throughout the entire State where they may hold office.

"AND WHEREAS, By virtue of their knowledge of the general requirements in a given instance being greater than that of the laity at large.

"AND WHEREAS, By reason of their office and intimate knowledge of the needs they are called upon to make suggestions during legislative sessions.

"*Resolved*, That in the opinion of the International Conference it is plainly the duty of the State Commissions to make such recommendations to their respective State legislatures as their experience in the practical workings of their laws regulating the taking of fish may dictate.

"*Resolved*, That the States are fully competent to make wholesome laws for the protection of their fish and game.

"*Resolved further*, That where in any case from lack of intimate knowledge of the habits and the place in the ecomony of nature of any given species of fish, the commissioners shall advocate such restrictive legislation as will leave no doubt as to its efficiency, until such investigation has been made as will enable them to give intelligent recommendations on the subject."

Dr. Sweeny presented the following resolution which was adopted, viz.:

"*Resolved*, That in the judgment of the conference, there should be a close season for bass, and that such season should be between the first of April and the 15th of June, and all kinds of fishing, including spearing, should be prohibited in the close season."

On the question of a close season for the commercial fish of the great lakes, after considerable discussion developing some differences of opinion, a committee of conference was appointed to formulate a report embodying the views of the committee, to be presented to the meeting for its action. This committee consisted of Messrs. William H. Bowman, W. P. An-

drus, J. C. Parker, E. W. Gould, C. M. Keyes, R. O. Sweeney, A. G. McDonald, Herschel Whitaker, with Samuel Wilmot as consulting member:

The committee reported as follows, and their report was accepted and adopted, viz.:

"1. That all small fish and others unfit for food, of all kinds, when taken in nets should be replaced in the waters when taken alive, that fishermen should not be allowed to take such fish on shore nor expose them for sale.

"2. That no strings of pound nets used in the lakes shall extend more than four miles from shore.

"3. That one-half part of all channels between islands or elsewhere, where fish migrate to spawn, shall be kept free from nets of all kinds at all seasons.

"4. That all whitefish taken of less than sixteen inches in length, and all salmon trout less than two pounds in weight, shall be immediately returned to the waters where taken and shall not be exposed for sale.

"5. That the month of November in each year be made a close season for whitefish, herring and salmon or lake trout.

"6. That all penalties fixed for violation of any laws that shall be enacted shall be made not only to apply to those who take fish, but also to all persons who buy, sell transport or have the same in possession."

The following resolution was also passed, viz.:

"*Resolved*, That the law should authorize the seizure and destruction of nets used in violation of law."

The members of the conference went, on the invitation of the Michigan Fish Commissioners, to visit the Detroit hatchery, and on the invitation of Mr. Wilmot, visited the hatchery at Sandwich, Ontario. An invitation was also extended to them by Mr. Clark to visit the U. S. hatchery at Northville, but as this necessitated remaining over another day, his courtesy had to be declined.

On the evening of December 21 a banquet, which had been tendered to the conference by the citizens of Detroit, was served at the Cadillac hotel. A beautiful spread was laid and upwards of thirty guests partook of the bountiful and elegant repast.

EELS.

In the summer of 1891 Mr. Orr D. Marks, overseer of the Paris station, with the car "Attikumaig" and four assistants, went to the Hudson river, near Troy, New York, to get silver eels for planting in Michigan waters. The car made two trips, bringing about 125,000 on the first trip and about 175,000 on the second trip. Mr. Marks left Paris June 9 and found the car and his assistants awaiting him at Detroit. They arrived at Troy June 11 and found the old grounds where they had taken eels before, all right, and shifted the car to Green Island so as to be near enough to the work to be able to live in the car. The bushes were put in the same day and the next morning they lifted 20,000 eels. On June 15 they had 150,000, but the next day lost half of them by their worrying themselves out in the floating boxes in which they were deposited. After that they put a bunch of willows, the same as the eels were caught in, into each box, and lost no more. June 20 the first load was taken to Michigan, as it was found the eels would not live if kept too long in the floating boxes. Two men were left to continue the catch. The first load was planted and the car left

Detroit on June 30 for the second trip, arriving at Troy July 1 and leaving the same day, arrived in Detroit on the return, July 2. The whole number planted was 273,000 and they were planted between June 24 and July 3. The detail of the plants is given in the appendix.

CARP.

No extended improvements or repairs have been required to be made to the ponds or buildings at the carp station, and the expenses for the last two years have not exceeded the estimates.

The demand for this fish has been fully as great as in former years. All applicants have been supplied except a few from whom no replies were received when notified that shipments would be made upon a certain date. It is not unlikely that we will be able to fill next year's orders with yearling carp. We will certainly be able to do so if the stock now on hand winters well.

In some localities much interest is being taken in the raising of these fish; in others no particular attention is paid to them. It seems quite possible that in the near future carp will become a staple upon the fish markets of the country. The following, taken from the December, 1892, number of the *American Fish Culture*, published at Alliance, Ohio, indicates that this fish has already appeared upon the markets of that state, and that it brings a fair price:

"LAKE ERIE CARP, THEIR PRICE, THE DEMAND FOR THEM."

"By the overflow and breaking away of ponds, the stocking of streams by fish commissioners with surplus carp from the hatcheries, the carp have worked their way into Lake Erie, have multiplied and thriven until, during the fishing season just closed, quantities of them were taken in the pounds as well as in the gill nets of the numerous individuals and companies who make a business of fishing in this great lake, which, by the way, is the great fishing ground in the chain of lakes, and is peculiarly the whitefish lake. What do these fishermen do with the carp when they have caught them? This is a pertinent question and its answer is of great interest to all those persons who have been raising carp. All fish taken are assorted and each kind, when there is enough of them, are put into boxes which hold two hundred pounds, and these boxes are then taken to the fish warehouses of merchants who make a specialty of shipping them to retailers, etc. Well, the carp are assorted in this same way and sent to these same merchants, who are not only glad to get them, but cannot get enough of them, and they very gladly pay the same price for them as they pay for the famous whitefish, which has always been considered the best fish in the lake. For instance, when the warehouseman paid six cents a pound by the box for whitefish, they then paid six cents a pound by the box for carp. In this connection I wish to say that many of the finest restaurants and hotels in this State today have German carp on their bills of fare as often as they can get the bill of fare to warrant it. I want to take an exception to their calling them German carp, they are no more German carp, than a child born of German parents, in this country is a German. They are American carp. Among the many restaurants in Ohio that have the carp regularly on their 'bill of fare' is the Strannahan restaurant in the Arcade building in Cleveland. This is one of the best conducted and most successful eating houses in that great city. Every day they feed thousands of people, including many of the epicures of the city who take their mid-day lunch there, and every other day *carp* is the fish on their bill of fare. Facts like these knock over the silly twaddle of writers who are seeking a cheap notoriety in condemning not only the carp, but the commissioners for bringing them to this country, and who know nothing of the merits of the fish, and have not attempted to learn. A few years more when the carp can be supplied regularly and in sufficient quantities to hotels and restaurants to answer their purpose and it will be one of the staple fish of this country, and the enterprise that furnishes them alive to the market will be well rewarded."

WHITE BASS.

On May 21, 1891, Mr. Walter D. Marks, the superintendeut, left Detroit for Winneconne, Wisconsin, where he had been the year before, for the purpose of continuing the experiment of hatching white bass. On arriving at Milwaukee he learned from the superintendent of the Wisconsin fish commission that the fishermen had taken their nets out of Wolf river at the instance of the game warden. They went together to Madison to see the game warden, who declined to allow any nets to be set in Wolf river at Winneconne, as he had some difficulty with getting the fishermen to withdraw their nets, and it would not do to let any nets go back there. Mr. Marks then arranged with the Wisconsin superintendent to operate jointly with him at Lake Mendota, near Madison, where the fish were very plentiful. The white bass were present also in large quantities at Winneconne, and Mr. Marks could have done his work there in a short time and with better success than at Madison, because he knew the grounds and the fish there were ripe. He spent one day at Winneconne and caught 270 white bass with hook and line. May 27 he moved to Madison, there he set nets off a bluff across the lake and found the fish in shoal water, from one to ten feet, and very numerous. He set twenty rods of nets close to the shore and caught thirty bass, all males and ripe. He then got a small seine and hauled it by hand and caught 70, all males. He then telegraphed to Winneconne and got more nets, and on May 28 set them in deeper water and there got females which were very large and ripe. He caught them for four days. On June 2 the first hatch was made. In water at 60° they hatched in 46 hours. He managed to set up a Chase jar and took two quarts of eggs off the boxes and put them into the jar and found they worked very well in the jar. He lost 500,000 that hatched in a box, owing to the screen being too coarse. The eggs and fry are so small it is difficult to retain them in any screen. He also lost about 200,000 by the bursting of a fine screen in a tank where he had them stored. He succeded in hatching 5,000,000 one half of which were turned over to the Wisconsin commission. The rest he placed in 25 cans of 100,000 each, and brought to Michigan and planted. They were put into the cans on June 6 at 10 a. m., not two hours old, and they were carried in these cans in good condition for 72 hours before planting. They were planted on June 9 in Goguac and Gourd Neck lakes, in Calhoun county; in Clear lake, Livingston county; in Gravel lake, Van Buren county, and in Orchard and Black Walnut lakes, Oakland county.

For details of plants see appendix.

THE AMERICAN FISHERIES' SOCIETY.

This society has been in existence upwards of twenty-one years but not all the time under its present title. It meets annually at different cities. Its membership is composed of persons engaged or interested in fish culture. Its annual meetings usually last two days. Papers prepared with much care are read at these meetings and discussions are had upon all sorts of points and questions involved in fish culture. The papers cover a wide range and treat of almost every subject of practical experience and much of scientific research connected with fish culture. The record of its transactions contains a history of almost all that is known or has been done in the progress of the art. Its meetings have been entertained by

papers and discussions from the most learned specialists, and from those of the broadest practical experience and knowledge. It has for several years numbered among its members the fish commissioners of the several states that have taken the greatest interest in the subject, to whom it has been an invaluable aid in disseminating the experience and knowledge acquired by each among them all. At the last meeting of this society held at the Holland House, New York city, the several fish commissioners of the United States were declared members of the society by virtue of their office. The United States Fish Commission and all its efficient corps of scientific and practical assistants have for several years been connected with the society and make it a point to attend when they can, and frequently prepare papers to be read at its meetings when they are unable to be present. The members of our board attend such of its meetings as they can. We regard this society as an important factor in the progress and success of fish culture.

Among the subjects discussed at the last meeting was that of planting fingerling trout instead of fry, and elicited much interest. On this subject papers were read by Mr. Frank N. Clark of the United States hatchery at Northville, Mr. Fred Mather of the New York commission, Mr. James Nevin of the Wisconsin commission, and Mr. Herschel Whitaker of our Board. The discussion was very general. Mr. Whitaker's paper appears in the appendix. The conclusion reached by the representatives of the states which have done most in the work, notably Wisconsin, New York, Pennsylvania and Michigan, was that in view of the unqualified success which had heen heretofore attained through fry planting alone, and the greatly added expense of rearing any considerable number of trout to be yearlings before planting, it was unadvisable and impracticable, when the work was carried on upon anything like a large scale, to supplant fry planting with that of yearlings, however well it might answer as an interesting experiment on a small scale.

Another subject that aroused much interest at the meeting was "Nationalism in State Fisheries" on which a paper was read by Mr. C. A. Chamberlayne of the Boston bar, or "State Control of State Fisheries" the subject of a paper read by Mr. Hoyt Post of our Board. The latter paper appears in the appendix. What gave rise to these papers, and aroused the interest that was felt in the subject, was the fact that the menhaden fishermen who had been made to suffer the state penalty for unlawful fishing with purse seines in Maine and Massachusetts waters for menhaden which they ground up into fertilizers, had undertaken under the guise of a brief and harmless looking act known as the Lapham bill, to have Congress extend the jurisdiction of the federal government and put under the control of the United States Fish Commission all fisheries in navigable waters. This bill was defeated through the energetic opposition of the Fish Commissioners of Maine, Massachusetts, New York and Michigan, and the zeal and untiring industry and efficient labors of the aforesaid Mr. C. A. Chamberlayne; but was again presented in a slightly modified form and again defeated. The outcome of the discussion elicited by the reading of these papers was the unanimous adoption of the following resolutions, viz.:

"*Resolved*, That this society regards with disfavor any movement looking towards the turning over to the United States government the work of the said commissions in propagating and planting fish, and in the regulation and protection of the fisheries in the several states. That the jurisdiction over fisheries within the territorial boundaries of each State belongs naturally to that State. That there is an abundant field for the

coöperative action of the State and of the general government in the propagation and distribution of food and game fish, and anything which would detract from the State's interest in this respect will be detrimental to the end aimed at of restocking the waters of this country; and we recommend a course which will encourage and stimulate greater interest and larger expenditures in this great work by the several States, and at the same time increased interest in the matter by the United States. And be it further

"*Resolved*, That the purposes and aims of this society are in direct antagonism with any business which leads to the depopulation of the waters to enrich the land, and we therefore condemn purse seining of Menhaden or any fish food, or food fish, for the purpose of grinding the same into guano or oil, within three miles of the shore, at low water mark."

Dr. J. C. Parker of our Board was vice president last year and as such presided over the last meeting.

The next meeting will be held at or near Chicago during the World's Fair.

Mr. Herschel Whitaker of our board was elected president of the society for the ensuing year.

EXAMINATION OF WATERS.

The work of systematic and thorough examination of the inland lakes and larger streams of the State, which was inaugurated in 1883, has been continued during the past two years. There were examined during the summer of 1891 in all 84 lakes and in 1892, 73 lakes, and our collection now aggregates upwards of 400 lakes which have been examined and of which we have the reports in bound volumes.

The reports of these examinations are the same as are fully described in our last report. They are of uniform size and are bound in volumes and indexed. The information furnished by them are in brief, the location, length, width, shape, depth and surroundings of the lake, character of shores and bottom, inlets and outlets and surroundings, kind of water and temperature at top and bottom, date of examination and condition of the weather at the time, number and kinds of fish caught and their condition and what they are feeding upon, the kinds and quantity of fish recommended to be planted, if any, and any other special information deemed of value. A blank space is left on the back of the reports on which a drawing s made showing the shape of the lake and the soundings taken, the location where the nets were set and the character of the shores and bottom.

The crews are provided with a canvas boat and tents and camping outfit, a gang of gill nets of different sizes of mesh, various kinds of fishing apparatus. a deep-sea self-registering thermometer, a dredge, a towing net of fine mesh and a lead and line for soundings.

The work in 1891 commenced May 28 and ended September 5. A double crew in charge of W. D. Sargeant and six assistants accompanied by Prof. Jacob Reighard, and his assistant, Mr. Hill, and a botanist, W. H. Rush, operated together in the central part of the State, in continuation of the regular examination. The force included, besides the overseer, four men, H. H. Marks, F. S. Sargeant, M. W. Gibbons and T. S. Dixon, to do the sounding and fishing, two working together in a boat—a second boat usually being hired at the lake—a cook, Charles Miller, and a teamster, John McKerlie. The outfit consisted of four tents, a team and wagon, an oil stove and cooking utensils, besides bedding and sleeping conveniences, and the necessary changes of clothing.

Prof. Reighard and his assistant, Mr. Hill, and the botanist, Mr. Rush, from the University of Michigan, accompanied the crew with books and

microscopes and a small laboratory of chemicals and appliances and utensils for scientific work and conveniences for preserving specimens. Their especial work consisted of examination and investigation of the aquatic vegetation and minute animalcules and the food and habits of the fish and the fish food and the fish parasites and the contents and characteristics of the waters generally.

This party usually selected a good camping ground near some large lake where they would remain a week or more until they had examined all the lakes within convenient distance, going each day with the team to the adjacent lakes and then with the team moving the camp to another similar camping place. In long moves it became necessary to hire an additional team.

Another crew of four men and a cook were employed from July 14 to to August 17, 1891, in some special work at Torch lake and adjacent waters.

In 1892 the examination of waters began June 27 and continued till September 23. The work was in charge of W. D. Sargeant and his assistants were J. P. Marks, Dwight Lydell, J. W. Powers, H. J. Sargeant, C. Miller, the cook. and John McKerlie, the teamster. The were accompanied by H. S. Jennings, assistant of Prof. Reighard of the University of Michigan, who devoted himself principally to the examination and preservation of the stomachs of the fish that were caught for later careful and minute microscopical investigation.

The Board are thoroughly convinced of the value and importance of this branch of their work and have already experienced great advantages from it in the information thereby obtained with reference to the suitableness of the waters for the planting of fish that are applied for in the lakes of which examinations have been made. This is the result of the mere routine, practical work; what the outcome of the more scientific work will be, it is too early yet to prophesy. Certain it is that it is impossible to know or to learn too much of the food, habits, enemies, organism and characteristics of fish, in the effort to make the greatest success of fish culture. The greatest lack has been in the greatest desideratum of accurate and scientific research and knowledge on these subjects. We are as yet only at the threshold of the inquiry. We have had only a bare glimpse here and there into the realms of knowledge that the future will open up to our nearer view.

A synopsis of the examination reports is given below:

REPORT OF STATISTICAL AGENT.

Mr. Charles H. Moore was appointed statistical agent of the commission to gather and compile the statistics of the fisheries of the State for the season of 1891. Statistics are of value when made each season for a series of years, serving to show the decay or renewal of the fisheries. To be of permanent value they should be carefully gathered and compiled for many years in succession. While the statistics of two or three successive seasons may show a decided increase or decrease when compared one with the other, they are of no special value when we take into consideration the varying conditions of season. One season may be peculiarly favorable for the setting or raising of nets, while the next may be characterized by the severity of its storms which preclude the lifting of the nets or which blow them out altogether, and thus no just comparison can be made. It is

peculiarly the duty of the department of fisheries, therefore, to see that proper data is gathered from year to year from which at the end of a given term it may be fairly predicted whether its work has been successful or not.

If, upon such information, the work is found not to have been successful information is often gained from which to determine the causes of failure. and means can be taken to correct the influences which prevent success.

The individual testimony of candid fishermen in different localities in the State indicates that the plants thus far made have been measurably successful, and where they have not been the report of the agent furnishes information as to the causes which have contributed to failure.

For convenience in instituting comparisons in the future, as to increase or decrease in the value of the fisheries of the State, it has been thought best to divide the coast into districts which are fixed as follows:

DISTRICT NO. 1.

Mouth of Detroit river to State line between Michigan and Ohio on Lake Erie.

DISTRICT NO. 2.

East shore of Lake Michigan from south line of Michigan to Hammond's bay on Lake Huron, including the south side of the Straits of Mackinaw.

DISTRICT NO. 3.

From the State line between Michigan and Wisconsin on Green bay, east around the north shore of the Straits of Mackinaw to Detour, including the Beaver islands.

DISTRICT NO. 4.

West shore of Lake Huron, from Hammond's bay south to the mouth of Detroit river.

DISTRICT NO. 5.

South shore of Lake Superior from Montreal river east to Detour.

The narrative and detailed report of the statistical agent follows:

To the State Board of Fish Commissioners:

Gentlemen—Having been appointed by your Honorable Board Statistical Agent, I proceeded under your instructions to make a complete canvass of the entire lake coast of the State.

By personal interviews with the fishermen I sought to learn everything pertaining to the fishing business in the different localities. I endeavored to learn as to the kinds of fish caught, the number of nets, boats, and all the outfits used in carrying on the enterprise, so that when completed my report would give as nearly as possible a full showing of the fishing industry of the State. This has never been done thoroughly since the board has been in existence. It is a matter of very great importance in determining what should be done to protect the planting of fish to restore the great lakes to their former wealth of fish food. In many respects the work of gathering this information has been pleasant and interesting, and it shows that the commercial fisheries are a most valuable industry to the State. The amount of fish food taken each year from the great lakes

upon which Michigan borders is very large, and these waters may be truly called nature's store house for a cheap and wholesome food supply for the people.

As I was compelled to follow the shores of these lakes to a great extent, the work was somewhat tedious, and it took considerable time to cover the whole coast, which is something over two thousand miles in length. My aim was to be thorough and exact so that the report should show the facts as near as I was able to get them. Whether this has been done well the individual reports now on file in your office must bear testimony.

These reports contain the catch of fish of each fisherman for the year of 1891, together with a detailed statement of everything used by him in carrying on his business and their value, also the number of men employed and wages paid. The aggregate of these reports will show the number of men engaged in fishing, boats of all kinds, both steam and sail, docks, fish houses, freezers or cold storage warehouses, and nets of all kinds, all of which will appear in the tabulated statements connected herewith.

I began this work December 1, 1891, going first to Monroe, following along down the coast of Lake Erie to the Ohio line, then back to Monroe and to the mouth of the Detroit river, thus completing the canvass of Lake Erie.

The principal part of the fishing in this district is done with pound net, about 200 being in use in 1891, also a few seines. There are no gill nets fished on this shore except by J. N. Dewey & Co., of Monroe. The catch consisted largely of herring, sturgeon, whitefish and pike. Next in importance come catfish, sucker and red horse, which, by the way, are now used to a considerable extent and are on sale in all the fish markets.

Fishermen of this section say the catch was not as good as it should have been because of the hot weather during the months of September and October. It was better however, than in 1890.

There is no longer any doubt as to the good results obtained from the planting of whitefish here. Near Mount Pleasant creek there was a good whitefish ground some years ago, but later on it was abandoned, the whitefish having disappeared almost entirely. This season the catch on this ground was fair again and it is the opinion of all the fishermen in this locality that their reappearance is due to the work of planting by the fish commissions.

The east shore of Lake Michigan or District No. 2 was the next ground of investigation and I began work in this district at New Buffalo. On my arrival I immediately began inquiries for fishermen and to my surprise found none actively engaged in the business here, neither had there been for the past three years.

Mr. V. N. Schwiem, who has lived there for many years made the following interesting statement:

"About fifteen years ago whitefish along this shore from Michigan City to St. Joe were abundant. We used to take them with seines by the wagon load during the months of May and June, when running in large schools in shallow water which is a peculiar habit of the whitefish. Pound nets, seines and gill nets were used here at one time. Gradually but surely the whitefish began to fall off until three years ago, when I sold all my fishing outfit. Since which time not a single net has been fished at this place." In fact no fishing of any importance has been done on this shore from Michigan City to St. Joe during the past three years, only a few scattering whitefish and sturgeon and some rough fish, such as suckers,

bull heads, etc., are now to be found in this locality which was once so bountifully supplied with the best commercial fish of the great lakes, the whitefish. "Without doubt," this gentleman says, "the cause of the decay was brought about by the gradual diminishing of the size of the meshes of the nets from year to year, until finally the destruction was made complete. This system of abuse is carried on by many of the fishermen on the shores of these great lakes and I shall discuss this more fully later on.

At St. Joseph the fishing is largely done with gill nets. A few pound nets are used here for a short time in the spring and fall of each year, mainly for the catch of sturgeon which were very plenty in and at the mouth of this river which empties into Lake Michigan at this place. This river affords them a favorite ground for spawning.

The sturgeon is a much more valuable fish since the curing of their meat by smoking has been introduced. This has brought their flesh into general use, it being preferred by many to smoked halibut. Caviare is also prepared from their ova and is quite valuable, being worth this season twenty to twenty-five cents per pound. There were about seven thousand pounds of caviare put up at this place in 1891 all of which was exported to Hamburg, Germany. There are five steam tugs fishing out of St. Joe with gill nets. They run out into the lake several miles setting nets in from forty to seventy fathoms of water. The principal catch on these grounds is the deep water trout, or "buckskin trout" and "long jaws," which are said to be a species of the herring, being somewhat larger and commanding a better price on the market than the herring. They are essentially a deep-water fish and they are taken in the same nets with the deep water trout. Here is also found a most loathsome looking fish called by the fishermen "lawyers" or eel pouts. They have but little commercial value. A few find sale, however, in the interior of the State, being shipped as bullheads and are skinned and prepared for market in the same manner as bullheads. In appearance and form they resemble it, but are much larger, reaching a weight from four to ten pounds each. It is the universal opinion of the fishermen that they are destructive to the trout and they are found in great numbers during the spawning season of the trout; they frequent spawning beds and feed upon the eggs of the trout there deposited. Many of the lifts of these tugs which I saw while at St. Joseph consisted of one-quarter to one-third of these fish. The same story of the whitefish is told here as at New Buffalo. Only a few years ago tons were shipped from this place each year, now not one pound. Again the use of small mesh nets is without doubt the cause.

South Haven is located at the mouth of Black river and is the next station north of St. Joe on this shore.

Only pound net fishing is done here and by one man. The principal catch is sturgeon. The meat is shipped to Chicago, and the ova is made into caviare for the German market.

Mr. Charles P. Paxton, who carries on the business at this place began his career years ago as a fisherman in the waters of lake Erie, then went to lake Huron and finally located here where he has been for some years past. Being a practical fisherman his experience has given him an opportunity to become familiar with the different kinds of fish inhabiting these lakes and their habits. He says of the whitefish: "I am sure the plants made in this locality for the last four or five years by the Michigan hatchery matured into the very whitefish I caught here during my spring fishing this season. There are some marked differences between the Lake

Erie whitefish and those of Lake Michigan which enabled me to be quite certain upon this point. This fact is conclusive proof to me of the great benefit derived from artificial planting. The whitefish had almost entirely disappeared from this locality and have only returned since the work of planting began."

Saugatuck, which lies at the mouth of the Kalamazoo river, and was at one time a good fishing station, is now of very little importance. Whitefish and sturgeon were the principal varieties caught here. Now about all that are left here of the fish kind are perch, which are very plentiful in and about the mouth of the river. In a southwesterly direction some four to six miles distant is a large whitefish spawning ground which is known by all the fishermen along this shore. The bottom is gravel and porous rock formation and is covered by two to four fathoms of water.

Located at the mouth of Grand river is the enterprising city of Grand Haven. The varieties of fish caught here and the manner of fishing is much the same as at St. Joe. Many more persons are engaged in the business here, however, and much larger shipments are made. Chicago is the market for all the fish caught here. Six tugs and eight sailboats, each equipped with a full complement of gill nets and men, constitute the outfits. There are also eight pound nets which are used for the catch of sturgeon. A light catch of sturgeon was made this season and the caviare obtained amounted to about 1,500 pounds. Deep water trout, "long jaws," "black fins," and perch are the principal kinds taken. Only 1,000 pounds of whitefish are reported to have been caught here this season.

Capt. Thomas W. Kirby, for many years a resident of this place, and well known to the vessel men all over these lakes, having been engaged in ship building for a long time, has recently turned his attention to the fishing business. For this purpose he has this season put in commission two steam tugs, has enlarged his cold storage house to a capacity of 250 tons and has put up an ice house which he estimates will hold 2,500 tons. Here, also, are found the most hated of all the fish kind on this shore, the "lawyers," in considerable numbers.

There is some fishing at Lake Harbor, between Grand Haven and Muskegon, the fishing being carried on by a resident of the latter place, which I visited next, obtaining the following information.

The vast amount of sawdust and edgings from the large number of saw mills located on the Muskegon river and at its mouth is carried by the current far out into the lake. It is claimed this is the principal cause of the the destruction of these once fairly good fishing grounds. The fishermen here claim that it was this alone that drove the whitefish away. Only two or three saw mills are now operated here and these consume all their dust, edgings and slabs for making steam. Gill, pound and fyke nets are in use here, also seines. "Long jaws" and perch compose the greater part of their catch. A few whitefish and sturgeon are taken and some rough kinds. Altogether the business here is of no great importance and those engaged in it are not able to gain a living by it alone.

Holland, located at the outlet of Black lake which empties here into Lake Michigan, is of little importance as a fishing station. A few nets are in use here, both gill and pound, with a light catch this season of lake trout, sturgeon, whitefish and herring.

Whitehall, or White Lake Harbor, as it is called by the people there, is located north of Holland on Lake Michigan. The character of the fishing here is much the same, only there are more persons here engaged in the

business, with much larger catches. "Long jaws, sturgeon, trout and whitefish are taken, ranking in importance in the order named.

Fishing at Pentwater is much the same as at Whitehall but the catch is considerably lighter,

The next station north is Ludington, at the mouth of the Pere Marquette river, well known for its large lumbering interests. The fishermen here are of one accord in saying it is the refuse from the saw mills that has destroyed and driven away the whitefish in this locality; they used to be very abundant. For the past few years, the catch of fish at this place has been insignificant and no whitefish at all are taken just at this point. The only fish tug owned here goes to the north shore during the fishing season, for the reason that it does not pay here. "Long jaws," "black fins" and deep water trout in limited quantities are the kinds taken here.

At Manistee, at the mouth of the Manistee river, the fishing is of more importance. I found here that there had been a light catch of whitefish. The principal catch was lake trout, with some "long jaws," "black fins" and a few sturgeon.

At Onekama, situated on Portage Lake, which has an outlet into Lake Michigan, three miles distant, fishing is of the same character as at Manistee, but with fewer engaged in the business and much lighter catches.

The next place north is Frankfort, on Aux-becs-scies or Lake "Betsy," the outlet of "Betsy" river, which is a good harbor just inside from Lake Michigan. Two steam tugs and six sailboats, with their equipments, carry on the business of fishing at this place and as far north as Otter creek, 22 miles distant on this shore. Their shipments this year amounted to about 400,000 pounds, composed of lake trout, whitefish and "long jaws," in the order given, with a very few sturgeon. Here whitefishing has fallen off, which is true of all the important stations along this shore. This point seems to hold out the best. The tugs here made all of two-thirds of the catch, fishing out 48 miles, near the south Fox island.

From Traverse City, taking in both arms of Big Traverse bay, then south from Cat Head Point to Leeland, Good Harbor, the Foxes, and the Manitous and Glen Haven, the fishing is carried on largely by Swedes and Norwegians. Pound nets and seines are principally used in the bay and along the shore between the islands above referred to and along the main land. Even at the north Fox and south Manitou, a few are in use. Largely, however, gill nets are used about these islands, and here is where the best catches are made in this locality. Here, again, I found the pound nets with their small meshes carrying on the work of destruction to the young whitefish. Here, also, the "long jaws" and "black fins" compose a very inconsiderable part of the catch, and the Mackinaw trout becomes an important factor, while the whitefish is in excess of any one kind, trout ranking next on the list. The two latter kinds make up almost the entire catch of this locality. The character of the fishing is much the same from Traverse City to Charlevoix, but with lighter catches.

Charlevoix is one of the most important fishing places on this shore. The shipments of fish from this place consist mainly of trout, deep water trout in the spring or early season, and Mackinaw trout in the fall. As an example of the magnitude of the business done here, it may be stated that on the 20th of November, 1891, one tug with nearly five miles of gill nets took at one lift 12,780, which were Mackinaw trout except two whitefish of from 7 to 9 pounds each in weight. The trout were also large, averaging

about the same weight. At this season of the year, the catch being large, prices drop off and a large proportion of them are frozen and put into cold storage for the winter trade. The freezers on this shore are owned and operated mainly by A. Connable & Sons of Petoskey. Their Petoskey cold storage houses have a capacity of 500 tons, those at Chicago 150 tons and at Cheboygan 100 tons. But a few pound nets are fished here.

Petoskey, located at the extreme end of Little Traverse bay, is quite prominent as a point from which large shipments of fish are distributed. The bay is fished with pound nets, while the tugs go outside with gill nets. Here the catch is much the same as at Charlevoix, trout being the prominent feature of the catch.

Following the shore up through the Straits of Mackinaw and down lake Huron to Hammond's bay the fishing is mainly done with pound nets except at Indian village and Cheboygan. At the former place, Indians with sailboats and gill nets do some fishing, but of no great importance.

Cross Village, once one of the best whitefish stations on this shore is now of little account, pound nets having fished it to death. The best catch of whitefish for some five years past was made this season at Waugoshance point and Hammond's bay. The kinds taken here are whitefish, trout, sturgeon and suckers, in the order named as to importance. There are quite a few "Menominees" caught in the straits, also out of Cheboygan. These so called mongrel whitefish, first made their appearance some years ago on the north shore of Lake Michigan, little if anything being known of them elsewhere in the great lakes. A most complete cold storage is located at Mackinaw City, its capacity being 150 tons.

The north shore of Lake Michigan, embracing the Beaver islands, the Cheneaux islands, and on to Detour being the 3d district was the next division taken up. I began at Menominee.

The character of the fishing at Menominee differs somewhat from that of the east shore. Pound nets are used more extensively along the shore than in any of the lakes upon which Michigan borders, except Saginaw bay. The wasteful manner in which they have been used in the destruction of small whitefish on this shore, and wall-eyed pike in Saginaw bay, is much to be deplored, giving a serious set back to these two most valuable kinds of fish. The catch of the pound nets consists mainly of whitefish, herring, wall-eyed pike, sturgeon and suckers. The gill net catch which is considerable, is principally done out of Manistique and the Beavers, and consists of trout, whitefish, and "Menominees." The largest catch of herring this season on this coast was made in Green bay. Covering a distance of 45 miles from Menominee north towards Escanaba, fifty pound nets were set, the aggregate of the catch being 1,500,000 pounds. It is a question in my mind however whether or not some of these were not small whitefish. I could not see for myself, being there early in May, after the season had closed and the fish shipped away.

The next herring fisheries of importance in this division are between Point Aux Chene along the shore to Gros Cap and to Pointe St. Ignace. The catch here this season was considerably less than at Green bay. Wall-eyed pike in this division are caught principally in Little and Big Bays De Noquette, in considerable numbers and fair size; sturgeon are also caught here and at other points along this shore, but to a very limited extent.

Manistique, located at the mouth of the Manistique river, was once noted for its great abundance of sturgeon, in fact it was a station of great

importance for all kinds of fish natural to these waters. It is still the headquarters for the largest shipments of fish on this shore. Most of the catch, however, is made some distance away. The water power here drives three large saw mills. The sawdust from these mills is carried out into the lake and covers the bottom for miles away, reaching well over toward the Beavers. To show the extent of the large deposits of sawdust and edgings from the mills here, it may be stated that it requires the constant work of a dredge during the season of navigation to dredge out the sawdust to enable steamers to get to the docks. The result of this has been to drive away and destroy all kinds of fish, except "suckers," which are of little account, and the fouling of the water is in direct violation of the State law. From all that I can learn of the past and present history of the whitefish, I am inclined to believe the most extensive and prolific grounds of all the great lakes were located on this shore. The almost fabulous catches related by the fishermen of St. Martins island, in Green bay, Manistique, Seul Choix, Mille Coquin bay, Naubinway, Epoufette, Gros Cap and St. Ignace have led me to this conclusion. The comparatively insignificant catches of the whitefish at the present time is traceable mainly to the causes heretofore mentioned.

The Big Beaver and the surrounding islands of the Beaver group, once famous for splendid catches of whitefish, have also fallen off, although shipments for 1891 from St. James were of no small importance. Pound and gill nets are fished here, and the character of the fishing is the same as along the north shore and among the Cheneaux islands to Detour.

Returning to Cheboygan and thence to Rogers City I began work in district No. 4, embracing the west shore of Lake Huron south from Hammonds bay taking in Saginaw bay, Saginaw river, St. Clair river and on to Detroit. From Hammonds bay to Alpena the fishing along the shore is comparatively light. Gill nets are mostly used and the catch is largely trout. The first appearance of wall-eyed pike on this shore is in the catches of the fishermen at Alpena located at the head of Thunder bay and continue to be an important factor in the business throughout this division extending from here on to Detroit. The principal points of distribution of the catch in this district are Alpena, Au Sable, Bay City, Port Huron and Detroit. The character of the fishing is much the same from Thunder bay to Saginaw bay. Tugs fish with gill nets out of Alpena, Au Sable and Sand Beach and report good catches for the season of 1891. A large proportion of the fish taken were trout. There was a fair amount of whitefish of good size and quality.

At Alpena the extensive use of the pound net begins following the shore of Lake Huron to Sand Point, on the west side of Saginaw bay. The pound net catch consists of whitefish, wall-eyed pike, suckers and sturgeon, of value to fishermen in the order named.

Visiting these fisheries in June, 1892, I have a personal knowledge of what they are doing in this locality. Tons of immature whitefish were taken in the pound nets here, many of them so small they could not be salted, neither could they be put upon the market and sold fresh, and as a last resort they were smoked. Could the millions of whitefish plants made by the hatcheries each year escape this most shameful manner of fishing, not only here, but in many other localities, until they attain a spawning age and a commercial size, the fruits of artificial propagation would be realized. Substantial protection should in some way be brought about in the interest of fishing as well as planting, thereby fostering one of the most important industries of the State.

Saginaw bay and river present peculiar characteristics in fishing which are not found elsewhere in the waters of these great lakes. The principal catch here is of what are termed "rough fish," and for the season of 1891 exceeded in quantity 6,000,000 pounds. The kinds taken are wall-eyed pide, grass pike, herring, suckers, bullheads, catfish and perch. At the Charities a few whitefish are caught, the most important kind comprising the catch here is the wall-eyed pike, its commercial value being about the same as that of whitefish. Tons of this fish find a market in New York city, and the south, standing long shipment distances better than any other kind of fresh water fish. Pound nets, fyke nets, drive nets, goblers, and seines, numbering something over 500, are fished in the bay and river. The twine used is two to two and one-half inch mesh.

So much has been said concerning the manner in which fishing has been conducted in Saginaw bay and river for years past in former reports that it seems hardly necessary to go over the ground again, but being an eye witness to the large catches here of wall-eyed pike so small that they are not sold by weight, but by the dozen, I feel that it is a matter of too much importance to be passed by without a word. During the fall and winter season the Saginaw river and the mouth of the Shiawassee river are completely lined with small pound nets, fykes and goblers. The "little pins," as the fishermen call them, seeking shelter in the river during this season of rough weather are caught by the tons. Many of them are left on the ice, being too small for any kind of use. Here again rises the necessity of some well considered law efficiently enforced for the protection of this valuable fish which is nearly, if not quite, equal in value to the whitefish, and which are propagated with less expense.

From Port Austin to Forestville gill nets are principally fished. From there on to St. Clair river pound nets. Their catches being trout, herring, sturgeon, whitefish, pickerel and perch.

From Port Huron to Marine City about one hundred skiffs, two men to each boat, are engaged in "bobbing" for pickerel. This fishing begins the last of May and extends through June into July. One dealer at Port Huron bought something over seventy thousand pounds caught in this way in the season of 1891. Some of these skiffs realize for a day's fishing as high as $10. With the exception of this style of fishing for profit in the St. Clair river seines only are used. Pickerel and suckers comprising the catch.

A line stretched across the north channel below Algonac with snoods or leaders one foot apart with a large hook at the lower end, the other end being attached to the line above referred to, lies on the bottom of the river, is a way for catching sturgeon peculiar to this locality. They are said to roll along over these hooks and when the fish are hooked their skin is so tough they do not often break away. Something over 20,000 pounds of sturgeon and 8,000 pounds of caviare were shipped from this point in 1891.

Baltimore bay is fished with small pound nets. Their catch consisting of perch and suckers almost entirely. Near the mouth of Clinton river quite a good haul of white bass were made in 1891 with seines.

Following the shore of Lake St. Clair to Windmill point fishing is carried on mainly with pound nets. The catch being largely pickerel and suckers, with light catches of whitefish and herring.

The fisheries at Belle Isle, Fort Wayne, Mammy Judy, Stony and Grassy islands are operated by the Michigan Fish Commission in the fall season for the purpose of artificial propagation only, as the whitefish are

making their way up the Detroit river to spawn. The catches are not large, but are of great importance in stocking the hatchery which is located at Detroit, and saves the expense of going further away for the eggs of the whitefish.

The last division of my work comprises the Sault Ste. Marie river and the coast of Lake Superior, known as district No. 5. The fishing is carried on here with gill nets and pound nets, the same as in all others of this chain of lakes, and the catch differs only in kind. The siskowet, a species of the trout family are caught in Lake Superior only, and make up a fair proportion of the catch. They are a deep water fish and resemble the trout, which are found, however, in shoaler water. The siskowet are much fatter and do not sell for as much on the market fresh. When salted they bring about the same price. The catch of fish on the Sault Ste. Marie river and among the islands at the head of Lake Huron is brought to Detour for shipment. Both gill and pound nets are used and the catch consists of trout, whitefish, pickerel and suckers, in numbers and importance in the order named. The muskalonge, once so plentiful on this river, has almost entirely disappeared. The best catches of whitefish in this locality are made at St. Joseph and Drummond islands.

The catch of whitefish at the Sault Rapids with dip nets and skiff was very near 100,000 pounds for the year 1891, and exceeded somewhat the catches of 1889 and 1890.

Located at Whitefish point are the most productive whitefish grounds anywhere to be found on Lake Superior. A better catch was reported here in 1891 than for the two or three preceding years. Four tugs fish gill nets out of this station, their catches being largely of siskowet and trout with a light sprinkling of whitefish.

At Grand Marias, Huron bay, Grand island, thence north to Marquette, the fishing presents about the same features, as to the manner of fishing and the kinds caught. Small gill nets, rigs and pound nets are used, with light catches of trout, whitefish, herring and siskowet. Three tugs and six sailboats fish gill nets.

Eight pound nets and two seines are fished out of Marquette, which in importance as a fishing station on the coast of Lake Superior, ranks next to Whitefish Point. Siskowet, trout, whitefish and herring are the product of these fisheries. The amount of the catch being in the order named.

From L'Anse, at the head of Keweenaw bay to Kenweenaw point, pound nets are mainly used, except at Portage Entry, where a settlement of Finlanders fish twenty-four sailboats equipped with gill nets. Some of them fish pound nets also. The catch in this locality is largely of whitefish, herring, and next and lastly, trout.

The best catches of whitefish in this neighborhood for the year 1891 were made at Baraga and Bete Grise.

Keweenaw bay and the shore lying on the east side of Keweenaw point is well adapted to the use of the pound net. Good catches of trout are made in the fall season at the Manitou island, which is but a short distance from Keweenaw point, and is said to be a natural spawning ground for them. No siskowet are reported in the catches here, for the reason, I suppose, that the sailboats do not go far enough out. I proceeded from this point to Copper Harbor, Eagle Harbor, Eagle river, Misery bay, Ontonagon (all being noted at one time as fishing stations of considerable importance) and then on to the Montreal river, where the

Michigan coast terminates. The catches for 1891 were very light. Nowhere on this lake did I find the depletion of the waters of the whitefish more marked. No tugs or large outfits are now fished from any of these stations, for the simple reason that it does not pay. Pound and gill nets are both used. The catches consist of whitefish, trout and herring, a large proportion being whitefish.

All the coast fisheries have been visited except those of Isle Royal, which are accessible only by boat from Duluth. It was thought best not to go there, on account of the long distance and the expense it would involve. I learned, however, that the fishing was carried on there by parties living at Duluth, and the information sought after could be had from them late in the fall when they came back from the island. I hope to get this information as to catch as nearly correct as possible without a personal interview. I am informed that the catch there consists chiefly of trout, and that three pound nets are fished in Washington Harbor; with this exception gill nets are used exclusively. The fisheries of this island were noted at one time for their large shipments of salt fish, but their catches now are much lighter, and for the past three or four season, or more they have been sent away fresh by boats making regular trips to the island twice a week during the season of navigation.

The magnitude of the fishing industry of the State may be better understood and more fully appreciated by an examination of the tabulated statement herewith submitted which shows as near as possible the exact catch the amount of capital invested in lands, buildings and fishing outfits for the year 1891, together with the product of all these fisheries in pounds, the value of same, the number of men employed.

The quantity, quality, and kind of food fish taken from these great lakes has no equal in any of the fresh water lakes of the world. Michigan may well feel proud of her extensive coast bordering upon these lakes, and of her most important fisheries giving employment to so many men. While seven-eighths of the fishermen reported better fishing in 1891 than for three or four years prior, especially in several localities, where the whitefish are taken, yet it was generally conceded by them all that a gradual depletion of fish in the lakes was going on from year to year. And here we come to the causes of the constant decrease.

The filling of the waters with sawdust, and the taking of small and immature fish which have never spawned I am convinced are the two prime causes. Both of these causes I have before referred to in this report, giving the locality where I found these causes standing out most prominent.

If the wasting away of this one of the most important industries of this State is to be arrested it should be done at once. While the hatcheries are doing all their present capacity will admit of in replenishing these waters, "chiefly with the plants of whitefish and wall-eyed pike," their work is to a great extent neutralized by the persistent catches of immature fish by the fishermen.

CHARLES H. MOORE,
Statistical agent.

DETAILED REPORT OF DISTRICT NO. 1.

Fish caught.	Pounds.	Value.
Whitefish	144,356	$8,328 36
Lake trout		
Pike perch	82,900	3,390 00
Herring	335,400	3,354 00
Sturgeon	22,260	1,018 50
Bass	920	55 20
Saugers	20,000	200 00
Perch		
Suckers	124,000	640 00
Catfish	16,000	372 00
Caviare		
All other kinds	6,400	64 00
Total	752,236	$17,422 06

Amount invested.

Value of nets	$40,550
Value of boats	11,805
Value of lands and buildings	5,925
Total	$58,280

Nets in use.	Number.	Fathoms.
Gill nets		
Pound nets	190	26,125
Seines		
Total	190	26,125

Boats in use.

Steamers	2
Sail boats	30
Pound boats	8
Skiffs	15
Total	55
Number of men employed	106

DETAILED REPORT OF DISTRICT NO. 2.

Fish caught.	Pounds.	Value.
Whitefish	1,098,402	$53,459 31
Lake trout	2,962,060	129,506 90
Pike perch	19,492	735 18
Herring	1,846,400	44,875 50
Sturgeon	170,110	8,766 90
Bass	6,640	318 40
Perch	68,950	1,482 00
Suckers	34,250	513 25
Caviare	27,662	5,202 90
All other kinds	189,510	5,146 30
Total	6,423,476	$250,006 64

Amount invested.

Value of nets	$138,830 50
Value of boats	98,699 00
Value of lands and buildings	58,263 00
Total	$295,792 50

Nets in use.	Number.	Fathoms.
Gill nets	18,665	1,005,681
Pound nets	501	48,271
Seines	39	1,676
Total	19,205	1,055,628

Boats in use.

Steamers	40
Sail boats	157
Pound boats	67
Skiffs	69
Total	333
Number of men employed	384

DETAILED REPORT OF DISTRICT NO. 3.

Fish caught.	Pounds.	Value.
Whitefish	1,669,790	$64,431 85
Lake trout	1,020,410	35,727 15
Pike perch	121,200	4,835 00
Herring	1,828,600	28,849 25
Sturgeon	89,586	3,159 58
Bass	800	42 50
Saugers	----------	----------
Perch	500	7 50
Suckers	74,400	846 75
Catfish	----------	----------
Caviare	----------	----------
All other kinds	330,700	9,708 25
Total	5,135,986	$147,607 83

Amount invested.

Value of nets	$96,061
Value of boats	26,289
Value of lands and buildings	52,816
Total	$175,166

Nets in use.	Number.	Fathoms.
Gill nets	5,887	332,524
Pound nets	415	74,396
Seines	2	167
Total	6,304	407,087

Boats in use.

Steamers	5
Sail boats	143
Pound boats	68
Skiffs	20
Total	236

Number of men employed	292

DETAILED REPORT OF DISTRICT NO 4.

Fish caught.	Pounds.	Value.
Whitefish	377,940	$17,473 65
Lake trout	1,378,800	63,398 50
Pike perch	2,414,353	76,233 57
Herring	3,459,500	36,203 50
Sturgeon	454,650	17,883 50
Bass	86,458	4,025 90
Saugers	50,150	924 50
Perch	1,943,350	19,552 25
Suckers	1,125,000	14,742 50
Catfish	143,290	3,327 55
Caviare	31,336	8,180 60
All other kinds	567,300	6,353 60
Total	12,032,127	$268,299 62

Amount invested.

Value of nets	$144,748 00
Value of boats	43,851 00
Value of lands and buildings	145,732 00
Total	$334,331 00

Nets in use.	Number.	Fathoms.
Gill nets	3,106	342,631
Pound nets	704	127,440
Seines	40	5,579
Total	3,850	475,650

Boats in use.

Steamers	6
Sail boats	88
Pound boats	104
Skiffs	384
Total	582

Number of men employed	1,464

DETAILED REPORT OF DISTRICT NO. 5.

Fish caught.	Pounds.	Value.
Whitefish	4,819,900	$207,503 50
Lake trout	3,772,500	146,569 50
Pike perch	153,243	7,429 76
Herring	353,000	4,037 50
Sturgeon	95,000	3,360 00
Bass	500	30 00
Saugers		
Perch	4,500	150 00
Suckers	34,500	390 00
Catfish		
Caviare		
All other kinds	137,900	5,222 00
Total	9,371,043	$374,692 26

Amount invested.

Value of nets	$102,871
Value of boats	79,590
Value of lands and buildings	58,930
Total	$241,391

Nets in use.	Number.	Fathoms.
Gill nets	6,828	682,473
Pound nets	218	28,199
Seines	9	753
Total	7,055	711,425

Boats in use.

Steamers	17
Sail boats	156
Pound boats	56
Skiffs	58
Total	287

Number of men employed	1,673

SUMMARIZED REPORT OF ALL DISTRICTS.

Fish caught.	Pounds.	Value.
Whitefish	8,110,387	$351,196 67
Lake trout	9,132,770	375,202 05
Pike perch	2,791,188	92,623 51
Herring	7,822,900	117,319 75
Sturgeon	831,606	34,188 48
Bass	95,318	4,472 00
Saugers	70,150	1,124 50
Perch	2,017,300	21,191 75
Suckers	1,392,150	17,132 50
Catfish	159,290	3,699 55
Caviare	58,999	13,383 50
All other kinds	1,232,810	26,494 15
Total	33,714,868	$1,058,028 41

Amount invested.

Value of nets	$523,060 50
Value of boats	260,234 00
Value of lands and buildings	321,666 00
Total	$1,104,960 50

Nets in use.	Number.	Fathoms.
Gill nets	34,486	2,369,309
Pound nets	2,028	298,431
Seines	90	8,175
Total	36,604	2,675,915

Boats in use.

Steamers	70
Sail boats	574
Pound boats	303
Skiffs	546
Total	1,493

Number of men employed	3,919

The interest in the fisheries is principally a public interest in a cheap and wholesome food supply.

Nature has stocked these inland seas for the use of man. They do not require cultivation at his hands for the bounteous supply they yield. Nature has here provided in its own way for a continuing and exhaustless store of food for our use, but the constant fishing without restraint upon modes has made a heavy drain upon the indigenous fish. To overcome this the State has, in the interest of its citizens, undertaken by a sufficient expenditure of money to restock these waters by artificial propagation. This restocking has been persistently carried on for some years, and if proper and intelligent laws are enforced against the taking of the small fish before they arrive at the age where they can reproduce their kind, there can be no question about the ultimate renewal of the fisheries of the great lakes.

Artificial propagation can never, under circumstances which permit the taking of the planted fish before they have spawned, and the taking of fish naturally spawned before they have come to the age of reproduction, effectually bring about a renewal of the fisheries of our lakes.

These small fish are of little or no market value, but if they were left in the waters for another year or so their increase in size and weight would make them merchantable. They would have then, too, performed the function of reproduction, which, with the aid of artificial means, would ere long make the fishing industry profitable everywhere.

Many of the fishermen have already come to this view and are ready to sanction just laws for the protection of the young fish, and it is believed that right action taken by the legislature in this regard will meet their approval.

The commissioners of fisheries in this State are in no wise interested in this matter beyond what they believe is the public concern. They have no desire to plant fish in the waters which may not be taken by the fishermen, but they do insist that their labors shall be met in a fair spirit by the fishermen, particularly as they are most interested pecuniarily, next to the people themselves, in the maintenance of the fisheries and they should consent to take nothing from the waters but fish of adult age.

The cupidity of the selfish fisherman should give away to his judgment, if he reflects and understands that a few years more of present modes of fishing must leave the waters of the great lakes nothing but mere waterways for the passage of our lake commerce, their valuable fisheries having passed into that stage of decay which now distinguishes Lake Ontario.

It is only within the last five or six years that the states and provinces bordering these waters have done anything like adequate work in restocking, and yet it is unquestionably the fact that had it not been for their efforts the fisheries would have reached a much lower ebb than that to which they have fallen.

If the State is willing to devote its money to the restocking of its waters, it should also take steps by the passage of just laws to protect this work, and fishermen who are not actuated by selfish motives should be willing to be governed by just and fair laws for the protection and preservation of the fisheries.

Let the fishermen understand that the public proprietorship in these fisheries is paramount to any right he may exercise or enjoy in them, and that it is against public policy that he should pursue methods of fishing which will in his lifetime ruin the industry he follows.

SCIENTIFIC WORK.

It has been well said by a recent writer in the *Century Magazine* that "scientific study has so richly increased the content of human knowledge, it is so practical in its results and so fascinating in its practice that its methods and spirit are rapidly pervading every field of intellectual activity."

It does not require any abstruse reasoning to reach the conclusion that in order to successfully perform artificially any function of nature the first step is to learn just what nature does and how it does it; and with bodies so small as fish eggs and the spermatazoa it requires the use of a microscope and one skilled in its use, and also familiar with the subject, to ascertain the relations of the parts and the functions of each, and how and when they perform their part in the work.

Appreciating the practical value of scientific investigation in the artificial propagation of fish, this Board employed Prof. Jacob Reighard, of the University of Michigan, to make microscopical examinations of the process of impregnation of fish eggs and of the growth and development of the embryo. In the course of his investigations he has accompanied our men to the fisheries during the taking of eggs both of the wall-eyed pike and of the whitefish. This enabled him to see just how the men handled the eggs and to determine the effect of each step in the work. His experiments have been of great aid to the practical workers by increasing their knowledge of the requirements and process of successful fertilization of the eggs.

One of the most important of his studies has been to determine what the difficulties are that beset the successful impregnation of the viscid eggs of the wall-eyed pike, and why it is that so large a percentage relatively of these eggs fail to hatch, and to devise a remedy. He has also conducted experiments to determine the period of vitality of the milt, both of the whitefish and of the wall-eyed pike, in water, after it is extruded from the fish; also the period within which the eggs must be impregnated, and the manner in which it is done, and the conditions most favorable to its accomplishment. The result of his experiments in this line are given in his article in the appendix, and they are very interesting and instructive.

During the summer of 1891 Prof. Reighard with an assistant, Mr. Charles Hill, and a botanist, Mr. W. H. Rush, accompanied our crew on examination of waters from about the first of June until about the first of September. Much good work was done in the way of investigating fish food and the characteristics and contents of the inland lakes which were visited.

It was ascertained during this season's work that the condition and characteristics of lakes in the same basin or river bottom were so similar, and that the frequent removals of the camp of the examining crew so broke up the continuity of the microscopical work, that it was concluded that the better way to pursue the scientific investigations was not to follow the examining crew hurriedly from lake to lake, but to camp upon a representative and typical lake of each chain long enough to investigate it exhaustively before moving to another; and that thus without visiting anywhere near all the lakes of the State a thorough investigation could be had of a limited number that would fairly represent the whole. With a view of carrying out such a plan, it was proposed to the regents of the University of Michigan, jointly with this Board, to fit out a small movable laboratory

and cabin to be used by Prof. Reighard and such assistants as he should need to continue his investigations during the season of 1892. For some reason unknown to us, perhaps the lack of funds, the board of regents did not look favorably upon the plan and declined to join us. The cost was greater than we felt warranted in expending alone, and the matter was necessarily postponed.

In lieu of this more extended plan, all that was done during the season of 1892, was to have an assistant of Prof. Reighard, viz., Mr. H. S. Jennings accompany the examining crew and take and preserve specimens, particularly of the stomachs of the fish caught, and their contents, for future careful microscopical investigations.

Prof. Reighard, in addition to the work in the field, has each season taken home with him to Ann Arbor a quantity of eggs, both of whitefish and wall-eyed pike, which he has hatched their in jars which he had put up for the purpose, watching carefully and noting particularly each change in the progress of development of the embryo.

The value of these investigations and experiments to practical fish culture cannot be over estimated, and the work that has thus far been done in this line by this Board has met the highest encomiums of those engaged in similar work in other states. Reasonable appropriations of money to be used in this way are justified by the results of the work done with like expenditures heretofore, and are evidences of a high and intelligent appreciation of the subject by the legislature that grants them.

LEGISLATION.

We desire to urge prompt action upon the appropriations for the support of the work of this Board. During the session of the legislature of 1890 and 1891 the members of the board and the superintendent and secretary felt required to visit Lansing many times before the appropriation was finally passed. When these appropriations are delayed they are liable to become entangled with other public bills and sometimes with private bills to which they bear no proper relation and the appropriation bills are then used as a lever to press forward and promote the passage of such irrelevant bills to the detriment of the cause of fish culture. The consequent delay in our plans for the season's work is very damaging, and at times nearly half the spring labor is retarded or even has to be abandoned through doubt of the outcome.

It has at times been matter of surprise how little the new members of the legislature know of the work of this board, and frequently even the members of the fisheries committees enter upon their duties with very little appreciation of the methods, efficiency and value of the work. It has been gratifying, however, to note the interest shown and the activity exhibited by nearly everyone who takes the pains to get correct information as to what has been and is being done by this Board in the great work of propagating and distributing fish.

Members of the legislature are cordially invited to investigate this work and are furnished with every facility in our power to aid in acquiring accurate knowledge of our work.

Every department of the work is open to inspection and is freely and gladly shown to any and every member who will take the pains to make the inquiry.

EXHIBITS.

A live fish exhibit was made at the Detroit exposition in 1891 which attracted a good deal of attention and favorable comment. Some changes from the previous exhibit were made in the setting of the aquaria, and some sodding done and planting of shrubs, flowers and aquatic plants made, which improved the appearance of the exhibit. The decorating was done by Mr. Robert Hopkin, the artist. The work of getting fish for the show commenced August 20, and the exhibit continued until September 5. The grayling were caught in the Hersey river and the brook trout, brown trout and mountain trout, were brought from the Paris station, together with the grayling, on the car "Attikumaig." There were 19 grayling, 12 large brook trout, 15 three years old, 25 two years old, 50 mountain trout, 15 large brown trout, 25 two years old, and 60 one year old. There were 10 large German carp, 50 of the spring hatch, and two cans of gold fish, including some old fish and some of the spring hatch, brought from the carp station at Glenwood.

The other varieties were caught in lake St. Clair and the Detroit river, the former being floated down in live crates. There were in all 25 aquaria. The kinds of fish exhibited, besides those above named, were black bass, white bass, rock bass, swamp bass, pike, pickerel, catfish, bullheads, sturgeon, suckers, sunfish, dogfish, sheep head, shiners, perch, turtles and frogs.

The aquaria consisted of tin tanks with glass sides so arranged as to have the light shine through the glass and water, so that the fish, and every movement of the body, fins, tail, and gills, was in full view, and a current of pure, clear water running into and discharging from each tank. The fish car "Attikumaig" was also on the exposition grounds, and attacted a good deal of attention and received many visitors. The men in charge of the exhibit ate and slept in the car. The attendants in charge were instructed to give particular attention to answering all reasonable inquiries, and to explain the nature and methods of the work of the commission. The different tanks were labeled to designate the different varieties of fish.

At the close of the exhibit the common fish which were left were given away, and the large carp, goldfish and trout were carried in the car back to the Paris station, where the large carp were utilized as scavengers in the trout ponds and found to answer the purpose well. They were kept in the ponds until the next year, when they were again brought to Detroit and exhibited at the exposition of 1892.

The Board had made all calculations upon making a like exhibit at the State fair of 1891, and was prepared to do so. But when the superintendent visited the grounds at Lansing, on September 1, to prepare the aquaria, he found that through some misunderstanding, the space occupied by our exhihit the year before had been let for other purposes, and the water pipes and connections, and waste pipes and plumbing, had been removed, and it was not feasible to make an exhibit then without considerable additional expense and trouble in fitting out, for which there was scant time, and so the matter was dropped for that year.

A similar exhibit was made during the Detroit exposition of 1892. Some changes were again made in the decoration and surroudings, so as to give some variety to the display. An experiment was also tried by reducing by nearly one-half the thickness of the tanks and it was found to

do away with the breakage of glass which before had given some trouble, while it brought the fish into still more clear view, and the fish seemed to do equally as well as before. Some very pleasing rock-work effects were produced by plastering furnace slag upon board surfaces built in irregular shapes to resemble natural rocks. The exhibit did not seem to pall on the taste, but was constantly surrounded by interested crowds who seemed never to tire of watching the movements and actions of the fish. It was the most popular attraction on the grounds.

In 1892 a very satisfactory exhibit was also made at the State fair at Lansing, where it excited as much attention and interest as it had before at the exposition and at the State fair of 1890. We believe these displays are not alone interesting and attractive to the public, but that they are useful in educating the people as to the habits of the fish and the methods of propagating them and keeping good the supply, and tend to arouse a general interest in the subject of fish culture which is valuable.

HISTORICAL.

COMMISSIONERS.

Under the act of 1873, George Clark of Ecorse, George H. Jerome of Niles, and Gov. John J. Bagley of Detroit, ex officio, were the first Commissioners. They held their first meeting and organized May 12, 1873. George H. Jerome resigned June 15, 1874, to become secretary and superintendent, and Andrew J. Kellogg of Allegan was appointed to fill the vacancy. This board was done away with by the reorganization act of 1875. Under the act of 1875 the Governor, on April 24, 1875, appointed Eli R. Miller for two years, Andrew J. Kellogg for four years, and George Clark for six years. Eli R. Miller was reappointed January 1, 1877, and retired at the expiration of his term, January 1, 1883, and John H. Bissell of Detroit was appointed to succeed him. Mr. Bissell retired at the expiration of his term, Jan. 1, 1889, and Hoyt Post of Detroit was appointed to succeed him. Andrew J. Kellogg's first term under the act of 1875 expired January 1, 1879, and he was reappointed for six years. He resigned June 1, 1884, to become secretary and Herschel Whitaker was appointed to fill the vacancy. His term expired January 1, 1885, and he was reappointed for six years and on the expiration of this term, Jan. 1, 1891, he was again reappointed for six years. George Clark died Oct. 14, 1877, and Dr. Joel C. Parker of Grand Rapids was appointed to fill the vacancy. His term expired January 1, 1881, and he was reappointed for six years, and at the expiration of that term, on January 1, 1887, he was again reappointed, and his present term expires January 1, 1893.

SUPERINTENDENT.

George H. Jerome was acting superintendent from the first organization of the commission, May 12, 1873, until June 15, 1874, when he resigned as commissioner and was regularly appointed superintendent and served as such until September 15, 1879, when his term expired and he refused a reappointment. James G. Portman of Watervliet was appointed Superintendent, September 15, 1879, to succeed Mr. Jerome, and served as such until September, 1882, when he was succeeded by Oren M. Chase. Mr. Chase served until November 11, 1883, when he was drowned in Little

Traverse bay while in the performance of his duties. Thereupon Walter D. Marks was made acting superintendent and served in that capacity until March 26, 1884, when he was regularly appointed superintendent, and has since then continued to serve in that capacity.

SECRETARY.

Geo. H. Jerome was secretary from the first organization of the Board, May 12, 1873, until September 15, 1879, when he withdrew from the commission and James G. Portman was appointed to succeed him. Mr. Portman acted as secretary until September, 1882, when he was dismissed. On February 19, 1883, Herschel Whitaker was appointed and served until June 1, 1884, when he resigned, and Andrew J. Kellogg was appointed to succeed him. Mr. Kellogg served as secretary until March 20, 1888, when he resigned, and George D. Mussey, the present secretary was appointed and has served ever since.

RAILROAD COURTESIES.

There has never been a report of the Fish Commissioners of this State since the work was first inaugurated in 1873 that has not contained an acknowledgment of courtesies and liberal treatment from the railroads of the State. As the work has increased, the opportunities of the railroads to grant such favors have greatly increased, but the limit of their liberality has not yet been reached and the favors thus far have been granted without stint. But for the aid thus generously extended by them during all these years to the work of our Board, the same measure of success could never have been attained with the means which were at hand.

This hearty co-operation of the railroads and their broad appreciation of the requirements of the work, have not only been a great encouragement to the commissioners, but have saved the State many thousand dollars annually.

Should they withhold these generous courtesies and require payment of the customary mileage for transportation, it would so much lessen the amount out of the annual appropriations which could be devoted to the expense of producing the fry, and unless increased appropriations were granted for this purpose would by so much curtail the work done. We wish the people of the State to appreciate and understand this liberal treatment as thoroughly as we do. Appreciating this generosity as we do, we have aimed not to call upon the railroads except for purposes legitimately within the requirements of the work, and while we admit to having heavily taxed their liberality we have sought never to abuse or misuse it. Our car has been attached to and hauled with passenger trains, on request, from one end of the State to the other, for three or four months of the year, without charge for mileage or for fares of our employés.

Especial thanks are due the following roads, viz., Grand Rapids & Indiana, Detroit, Northern & Lansing, Chicago & West Michigan, Michigan Central, Flint & Pere Marquette, Detroit, Grand Haven & Milwaukee, Grand Trunk, Toledo & Ann Arbor, Chicago & Grand Trunk, Duluth, South Shore & Atlantic.

EXAMINATION OF INLAND LAKES 1891.

ALLEGAN COUNTY.

Big lake, Watson township:
Length, 1 mile; width, $\frac{1}{3}$ mile; greatest depth, 36 feet.
Shores high, wooded, mostly sand and gravel beach, some marsh.
Bottom, soft and muddy.
Inlets and outlets, none; fed by springs.
Dates of examination, June 1, 2 and 3.
Weather, clear.
Temperature, surface, 72°; bottom, 64°.
Fish taken, black bass, bullheads, suckers, bluegills and perch.
Fish small and stomachs empty.
Would recommend for planting eels and native fish.

Green lake, Leighton township.
Length, $1\frac{1}{2}$ miles, width, $1\frac{1}{4}$ miles; greatest depth, 68 feet.
Shores, high with timber on east side; cleared on south end and west side; sand and gravel beach.
Bottom, hard, clay, gravel and marl.
Inlets, none; outlet, branch of Rabbit river.
Dates of examination, June 2 and 3.
Weather, cloudy and rainy.
Temperature, surface 70°; bottom 40°.
Fish taken, perch, rock bass, blue gills, bullheads, pickerel and black bass.
The fish were all large, hard and fat.
Would recommend salmon trout and wall-eyed pike for future planting.

Selkraig lake, Wayland township:
Length 1 mile, width $\frac{1}{3}$ mile; greatest depth 37 feet.
Shores mostly high and wooded, sand and gravel beach.
Bottom hard clay and marl.
No inlet or outlet.
Dates of examination, June 3 and 4.
Weather cloudy and cold.
Temperature, surface 64°; bottom 44°.
Fish taken, perch, black bass, bullheads and bluegills.
The fish were hard and fat; perch very large.
Would recommend wall-eyed pike and eels for future planting.

McDougal lake, Watson township:
Length $\frac{1}{2}$ mile, width $\frac{1}{4}$ mile.
Shores, a low tamarack swamp.
Bottom soft and muddy.
No inlet or outlet.
Date of examination, June 4.
Weather cloudy with rain.
Temperature, surface 67°; bottom 44°.
No fish taken.
No recommendation as to future planting.

Miller lake, Watson township:

Length $\frac{3}{4}$ mile, width $\frac{1}{4}$ mile; greatest depth 30 feet.
Shores, a low tamarack swamp nearly all around.
Inlets, two, not named; outlet, a good sized stream, not named.
Date of examination, June 4.
Temperature, surface 70°; bottom 45°.
Weather cloudy.
No fish taken.
Would recommend eels for future planting.

Drummond lake, Allegan and Monterey townships:

Length $1\frac{1}{4}$ miles, width $\frac{1}{2}$ mile; greatest depth 48 feet.
Shores mostly low and marshy, high on north side, marl and gravel beach where high.
Bottom hard clay and sand, some marl.
Inlets, two, not named; outlet, one, which empties into Kalamazoo river.
Dates of examination, June 6 and 7.
Weather, 6th cloudy and cold; 7th clear.
Temperature, surface 64°; bottom 50.
Fish taken, perch, bluegills, sunfish and rock bass.
The fish were hard and the perch large.
Would recommend eels for future planting.

Miner lake, Allegan township:

Length $1\frac{1}{4}$ miles, width $1\frac{1}{4}$ miles; greatest depth 80 feet.
Shores mostly high and wooded; sand, gravel and marl beach, marl being soft.
Bottom hard clay, gravel and sand.
Inlet, one small stream; outlet, one, which empties into Kalamazoo river.
Dates of examination, June 5, 6, 7 and 8.
Weather, 5th, 7th and 8th clear, 6th cloudy and cold.
Temperature, surface 66°; bottom 44°.
Water, clear.
Fish taken, pickerel, large mouth black bass, perch, bluegills, grass pike, sunfish, rock bass, dogfish and suckers.
The pickerel were large, from 7 to 10 pounds; bullheads large, all other fish small.
Would recommend wall-eyed pike and eels for future planting.

Upper Scott lake, Lee township:

Length $\frac{3}{4}$ mile, width $\frac{3}{4}$ mile; average depth reported to be 12 feet.
Shores high, except around inlet; beach, sand.
Bottom, sand.
Inlet, one from Scott lake; outlet, one into Black river.
Date of examination, June 9.
Weather clear, water clear.
Temperature not taken.
No fish taken.
No recommendation as to future planting.

Osterhout lake, Lee township:
Length $\frac{3}{4}$ mile, width 100 rods; greatest depth 36 feet.
Shores high on north side, soft, muddy beach.
Bottom, soft and muddy.
Inlet, none; outlet, one into Black river.
Date of examination, June 9.
Weather clear, water cloudy.
Temperature, surface 70°; bottom 68.°
No fish taken; food seemed scarce.
Would recommend eels for future planting.

Clear lake, Lee township:
Length 80 rods, width 40 rods; greatest depth 18 feet.
Shores, a low, muddy beach.
Bottom soft and muddy.
No inlet or outlet.
Date of examination, June 9.
Weather clear, water cloudy.
Temperature, surface 72,° bottom 69.°
No fish taken.
No recommendation as to future planting.

Crooked lake, Clyde township:
Length $1\frac{1}{4}$ miles, width $\frac{3}{4}$ mile; greatest depth 20 feet.
Shore low nearly all around, except on east side.
Bottom muddy.
Inlet, none; outlet, one that empties into Black river in high water.
Date of examination, June 9.
Weather clear, water roily.
No fish taken, and no recommendation as to future planting.

Emerson lake, Trowbridge township:
Length $\frac{3}{4}$ mile, width $\frac{1}{4}$ mile; greatest depth 32 feet.
Shores high on north and south sides, low on east and west ends.
Bottom, muck.
Inlet, one small creek.
Outlet, one.
Date of examination, June 10.
Weather clear; water roily.
Temperature, surface 70°; bottom 52°.
No fish taken and no recommendation as to future planting.

Minkler lake, Trowbridge township:
Length $\frac{3}{4}$ mile, width 100 rods; greatest depth 45 feet.
Shores high on north side, the balance low and marsh; beach, sand and marl.
Bottom, sand and marl.
No inlet or outlet.
Date of examination, June 10.
Weather clear, water roily.
No fish taken and no recommendation as to future planting.

Base Line lake, Trowbridge township:
Length $1\frac{1}{4}$ miles, width $\frac{1}{4}$ mile; greatest depth 40 feet.
Shores, high bluff on north end, balance of shore lower and timbered.
Bottom, sand and marl.
Inlet, one small stream.
Outlet, one, a branch of Pine creek emptying into Kalamazoo river.
Dates of examination, June 10 and 11.
Weather clear, water cloudy.
Temperature, surface 72°; bottom 46°.
Fish taken, black suckers.
The fish taken were in good condition.
Eels recommended for future planting.

Duck lake, Cheshire township:
Length $\frac{3}{4}$ mile, width $\frac{1}{2}$ mile; greatest depth 30 feet.
Shores high, sand and marl beach.
Bottom muddy and soft.
Inlet, one from Muskrat lake.
Outlet, one into Swan lake.
Dates of examination, June 10 and 11.
Weather, 10th cloudy, 11th clear, water roily.
Temperature, surface 74°; bottom 64°.
Fish taken, perch, bluegills, sunfish, bullheads and pickerel.
The fish were large and in good condition.
Eels recommended for future planting.

Swan lake, Cheshire township:
Length $\frac{3}{4}$ mile, width $\frac{3}{4}$ mile; greatest depth.
Shores low and muddy on the beach; high and wooded fifty feet back.
Bottom muddy.
Inlets, two coming from Base Line and Eagle lakes.
Outlet, one large stream into Kalamazooo river.
Dates of examination, June 8, 9, 10, 11 and 12.
Weather clear except on the 10th, when it was cloudy.
Water roily on the 8th and cloudy on the other days.
Temperature, surface 68°; bottom 64°.
Fish taken, perch, black bass, bluegills, speckled bass, pickerel, sunfish and bullheads.
Fish were soft, wormy, muddy tasting and very poor.
Eels recommended for future planting.

Eagle lake, Chesire township:
Length $1\frac{1}{4}$ miles, width $\frac{1}{2}$ mile; greatest depth 60 feet.
Shores, high and wooded with sand and gravel beach.
Bottom sand and gravel.
Inlet, one from Muskrat lake.
Outlet, one, into Swan lake.
Dates of examination, June 11 and 12.
Weather cloudy on the 11th, clear on the 12th, water clear.
Temperature, surface 71°; bottom 44°.
Fish taken, perch, bullheads, speckled bass, rock bass, dogfish, mud bass and sunfish.
Fish in good condition, hard and fat.

Recommend wall-eyed pike, small mouth bass and eels for future planting.

Hutchins lake, Ganges and Clyde townships:

Length 1¼ mile, width ½ mile; greatest depth 35 feet.
Shores high with sand beach.
Bottom sand and marl.
Inlets, two small streams.
Outlet, one, into Black river.
Dates of examination, June 13 and 14.
Weather clear, water cloudy.
Temperature, surface 72°; bottom 61°.
Fish taken, perch, black bass, rock bass, speckled bass, bullheads and suckers.
Fish in good condition, large and fat.
Eels recommended for future planting.

ANTRIM AND GRAND TRAVERSE COUNTIES.

Elk lake, Elk Rapids and White Water townships:

Length 9½ miles, width 1½ miles; greatest depth 170 feet.
Shores, east and west, gravelly; north and south, sandy.
Inlets, three on the south, viz., Battle creek, Follet's creek and third not named; outlet Elk river.
Dates of examination, July 16 to 22 inclusive.
Weather warm except on the 17th and 18th when it was cold, water clear.
Temperature, surface 64°; bottom 53°.
Fish taken, whitefish, herring, ling, rock bass, grass pike, salmon trout, suckers and perch.
Trout and whitefish well fed and showed large growth, rock bass very large, perch very small and poor.
Recommend whitefish, salmon trout and wall-eyed pike for future planting.

ANTRIM COUNTY.

Clam lake, Helena township:

Length 4 miles, width 80 rods; greatest depth 23 feet.
Shores sandy on north and south; east, low and marshy; west, sand and gravel.
Bottom, black muck from three to six feet deep and covered with weeds.
Inlets, two at east end, Grass river and a small creek with no name; outlet, Clam river.
Dates of examination, Aug. 5, 6 and 7.
Weather warm, water clear.
Temperature, surface 72°; bottom 64.°
Fish taken, grass pike, rock bass, perch, bullheads, and bluegills. The rock bass were very large, the other fish small but well fed.
Eels, bass, carp, or native fish, recommended for future planting.

Grass lake, Forest, Home, Kerney, Helena and Custer townships:

Length 4 miles, width 1 mile; greatest depth 85 feet.
Shores, west side, high land, beach sandy; east side, low, beach soft marl; north and south ends, low and marshy.

Bottom, hard clay and gravel in center; north and south ends, soft marl; east and west sides, clay.
Inlets, two small streams at north end, Intermediate river, and two streams not named on east side; outlet, Grass river.
Dates of examination, Aug. 8, 9, 10, 11.
Weather clear and warm on 8th and 11th, windy and warm on 9th and 10th.
Temperature, surface 71°; bottom 48.°
Fish taken, perch, lake trout, herring, grass pike, rock bass, and small mouth bass. The lake trout were soft but well fed, and showed large growth. The herring were very small but well fed. The other fish were well fed and showed large growth.
Eels, bass, and wall-eyed pike recommended for future planting.

Intermediate lake, Center, Lake, Echo, Kinney and Forest Home townships:
Length 7 miles, width $\frac{3}{4}$ mile; greatest depth 22 feet.
Shores, a cedar and tamarack swamp from 10 rods to $\frac{1}{2}$ mile in width surrounds the lake, back of the swamp the land is high.
Bottom, south end marl; north end soft mud from two to five feet deep and covered with weeds.
Inlets, eight; one on the north, four on the east, and three on the west, none of which are named.
Outlet, Intermediate river.
Dates of examination, August 12 and 13.
Weather and water clear.
Temperature, surface 71°; bottom 71°.
Fish taken, perch, rock bass, small mouth bass, grass pike, sunfish and suckers.
All fish were well fed and showed large growth.
Eels and carp recommended for future planting.

BARRY COUNTY.

Crooked lake, Prairieville and Barry townships:
Length 1 mile, width $\frac{1}{3}$ mile; greatest depth 48 feet.
Shores high and wooded, sand and gravel beach, marshy in spots.
Bottom clay, marl and black muck.
Inlet, none, fed by springs.
No outlet.
Dates of examination, May 28 and 29.
Weather clear on the 28th, cloudy on the 29th.
Water clear on the 28th, roily on the 29th.
Temperature, surface 63°; bottom 54$\frac{1}{2}$°.
Fish taken, perch, bluegills, bullheads and black bass.
The fish were small except the bullheads, which showed good growth.
Eels, pickerel and black bass recommended for future planting.

Pine lake, Prairieville township:
Length 2$\frac{1}{2}$ miles, width $\frac{3}{4}$ mile; greatest depth 48 feet.
Shores high and wooded with gravel beach.
Bottom sand and clay.
No inlet or outlet, fed by springs.

Dates of examination, May 30 and 31 and June 1.
Weather and water clear.
Temperature, surface 70°; bottom 63°.
Fish taken, black bass, perch, bullheads and bluegills.
The black bass averaged ¾; the perch were large. The stomachs of all fish were nearly empty, and it could not be determined upon what they were feeding.
No recommend as to planting.

Duncan lake, Thornapple township:
Length 2 miles, width ¼ mile; greatest depth 58 feet.
Shores high and timbered on west side with sandy beach; east side mostly low.
Bottom hard clay and marl.
Inlets, two small streams.
Outlet, one into Thornapple river.
Dates of examination, June 29 and 30.
Weather and water clear.
Temperature, surface 77°; bottom 42°.
No fish taken.
Wall-eyed pike and eels recommeded for future planting.

CLINTON COUNTY.

Round lake, Victor township:
Length ¾ miles, width ½ mile; greatest depth 25 feet.
Shores high on north and east with sandy beach, balance low and marshy.
Bottom soft black mud.
No inlet or outlet.
Date of examination, August 1.
Weather and water clear.
Temperature, surface 73°; bottom 67°.
No fish taken.
Eels recommended for future planting.

Park lake, Bath township:
Length 1 mile, width ½ mile; greatest depth 23 feet.
Shores high with sand beach, except on west side which is low and marshy.
Bottom soft and muddy.
Inlet, none; outlet, one small stream.
Dates of examination, August 1 and 2.
Weather clear, water roily.
Temperature, surface 72°; bottom 65°.
Fish taken, bullheads, bluegills, sunfish, black bass and speckled bass.
The fish were small and poor.
Eels recommended for future planting.

GENESEE COUNTY.

Silver lake, Fenton township:
Length 1 mile, width ¾ mile; greatest depth 61 feet.

Shores high with sand beach except on south side which is low and muddy.
Bottom hard, sand and gravel.
No inlet; outlet, one into Pinery lake.
Dates of examination, August 6 and 7.
Weather and water clear.
Temperature, surface 79°; bottom 46°.
Fish taken, bluegills, perch, sunfish and bullheads.
Fish small and feeding on crustaceans.
Wall-eyed pike and eels recommended for future planting.

Lobdell lake, Argentine township:
Length 1¼ miles, width ¾ mile; greatest depth 65 feet.
Shores high with mostly sandy beach.
Bottom marl, gravel and black muck.
Inlets, three small streams.
One large outlet flowing into Shiawassee river.
Dates of examination, August 6 and 7.
Weather and water clear.
Temperature, surface 75°; bottom 42°.
Fish taken, perch, black bass, bluegills, sunfish and bullheads. All were small.
Wall-eyed pike recommended for future planting.

Long lake, Fenton township:
Length 3 miles, width 1 mile; greatest depth 95 feet.
Shores high all around with sand and gravel beach.
Bottom hard, gravel, sand, clay and marl.
No inlet or outlet.
Dates of examination, Aug. 5, 6, 7 and 8.
Water and weather clear.
Temperature, surface 74°; bottom 49°.
Fish taken, pickerel, black bass, bluegills, sunfish, perch, bullheads, gar pike, and speckled bass.
The fish were small except the bluegills, which were large and fat, feeding on crustaceans.
Wall-eyed pike and eels recommended for future planting.

INGHAM COUNTY.

Pine lake, Meridian township:
Length 1¼ miles, width ¾ mile; greatest depth 30 feet.
Shores high with sandy beach on north and west sides, balance low and marshy.
Bottom marl and black muck.
No inlet; outlet one small stream.
Date of examination, Aug. 1.
Weather clear, water roily.
Temperature, surface 71°; bottom 68°.
No fish taken.
Eels recommended for future planting.

IONIA COUNTY.

Long lake, Orleans township:
- Length 1½ miles, width ½ mile; greatest depth 52 feet.
- Shores high and wooded, mostly sand beach.
- Bottom marl, sand and black muck.
- Inlet, one small stream.
- Outlet, one large stream.
- Dates of examination, July 24, 25 and 26.
- Weather and water clear.
- Temperature, surface 72°; bottom 53°.
- Fish taken, speckled bass, rock bass, bullheads, black bass and bluegills.
- The black bass were in good condition, other fish small and poor.
- Wall-eyed pike and eels recommended for future planting.

Morrison lake, Boston and Campbell townships:
- Length 1½ miles, width ¾ mile; greatest depth 20 feet.
- Shores, high with sand and gravel beach except on southwest which is low and marshy.
- Bottom soft and muddy.
- Inlet, one small stream.
- Outlet, one small stream flowing into Grand river.
- Dates of examination, July 28, 29 and 30.
- Weather clear, water clouded.
- Temperature, surface 74°; bottom 72°.
- Fish taken, speckled bass, bluegills, sunfish, bullheads and dogfish.
- The fish were small and poor.
- No recommend as to planting.

KALKASKA COUNTY.

Round lake, Clear Water township:
- Length 3 miles, width 1 mile; greatest depth 23 feet.
- Shores, east and southeast, swampy; south and west, some gravel; northwest, swamp; north, sandy.
- Bottom sand and marl.
- Inlets, three not named, Torch river on the east.
- Outlet, the narrows between Round and Elk lakes.
- Dates of examination, July 23, 24 and 25.
- Weather 23, warm and still; 24 and 25, cold and windy; water clear.
- Temperature, surface 70°; bottom 69°.
- Fish taken, grass pike, suckers, bluegills, sunfish, rock bass and perch.
- The fish were well fed and showed large growth.
- Recommend eels, carp and bass for planting.

KENT AND OTTAWA COUNTIES.

Cranberry lake, Wright and Alpine townships:
- Length ¾ mile, width ⅓ mile; greatest depth 27 feet.
- Bottom soft and muddy.
- Inlet, one small stream on east end.
- Outlet, one small stream on west end.
- Dates of examination, June 22 and 23.

Weather clear; water cloudy.
Temperature, surface 80°; bottom 72°.
Fish taken, bluegills, sunfish, speckled bass, dogfish and suckers. Fish poor.
No recommend as to planting.

KENT COUNTY.

Muskrat lake, Grattan township:
Length ½ mile, width ¼ mile.
Shore on west and north low, on east side, beach.
Bottom soft and muddy.
No inlet or outlet.
Date of examination, July 15.
Weather and water clear.
Temperature, surface 73°; bottom 49°.
No fish taken.
No recommend as to planting.

Pine Island lake, Grattan township:
Length 1½ miles, width 100 rods; greatest depth 40 feet.
Shores, mostly wooded, sand and gravel beach, heavy rushes all around.
Bottom marl, sand and muck.
Inlet, one small stream.
Outlet, one, into Muskrat lake.
Dates of examination, July 14 and 16.
Weather and water clear.
Temperature, suface 75°; bottom 49°.
Fish, black bass, speckled bass, bluegills, sunfish, bullheads.
The fish were in good condition.
Eels recommended for future planting.

Scram lake, Oakfield township:
Length ¾ mile, width ½ mile; depth 45 feet.
Shores low on north and south sides; east and west high; beach soft and muddy all around.
Bottom soft, black muck.
No inlet and outlet.
Date of examination, July 17.
Weather clear, water roily.
No fish taken.
No recommend as to planting.

Long lake, Oakfield township:
Length 1 mile, width ¼ mile; greatest depth 40 feet.
Shores high except on northwest, which is low and sandy.
Bottom sand and soft mud.
No inlet or outlet.
Date of examination, July 17.
Weather and water clear.
Temperature, surface 75°; bottom 44°.
No fish taken.
Would recommend wall-eyed pike for future planting.

Wabasis lake, Oakfield township:
Length 1½ miles, width 1 mile; greatest depth 55 feet.
Shores high and wooded; beach soft muck and marshy.
Bottom hard.
Inlets, two small streams on north side and four on the south side.
Outlet, Wabasis creek.
Dates of examination, July 16, 17, 18 and 19.
Weather and water clear.
Temperature, surface 74°; bottom 48°.
Fish taken, herring, black bass, bluegills, perch, bullheads, speckled bass, sunfish and pickerel.
All the fish were in good condition and showed large growth.
Wall-eyed pike and eels recommended for future planting.

Zingrafust lake, Oakfield township:
Length ¾ mile, width ¾ mile; greatest depth 40 feet.
Shores, high on south side; balance low and marshy.
Inlet, one small stream.
Outlet, one large stream into Wabasis creek.
Date of examination, July 19.
Weather and water clear.
Temperature, surface 74°; bottom 42°.
Fish taken, herring, rock bass, suckers.
Fish in good condition, hard and fat.
Wall-eyed pike and eels recommended for future planting.

Woodbeck lake, Oakfield and Spencer townships:
Length ¾ mile, width 100 rods.
Shores high.
Bottom marl and sand.
Inlet, one large stream from Lincoln lake.
Outlet, one into Horseshoe lake.
Date of examination, July 20.
Weather clear, water muddy.
Temperature, surface 75°; bottom 63°.
No fish taken.
No recommend as to planting.

Blue lake, Oakfield township:
Length ½ mile, width ¼ mile; greatest depth 52 feet.
Shores high.
Bottom marl and sand.
No inlet or outlet.
Date of examination, July 20.
Weather and water clear.
Temperature, surface 73°; bottom 44°.
No fish taken.
Wall-eyed pike recommended for future planting.

Myers lake, Courtland township:
Length ¾ mile, width ¼ mile; greatest depth 40 feet.
Shores high, sand beach all around.
Bottom sand and black muck.

No inlet or outlet.
Date of examination, July 20.
Weather cloudy, water clear.
No fish taken and no recommend as to planting.

Bass lake, Spencer township:
Length $\frac{3}{4}$ mile, width $\frac{1}{2}$ mile; greatest depth 20 feet.
Shores high with sand beach.
Bottom soft and muddy with some sand.
No inlet or outlet.
Date of examination, July 21.
Weather clear, water roily.
No fish taken.
No recommend as to planting.

Muscallonge, Mud, Blue, Little Lincoln and Massilion lakes, Spencer township:
A chain of lakes 2 miles long and $\frac{1}{2}$ mile wide; greatest depth, 40 feet.
Shores high.
Bottom mostly hard gravel with some sand and marl.
Inlet, one small stream.
Outlet, one into Lincoln lake.
Date of examination, July 22.
Weather and water clear.
Temperature, surface 73°; bottom 44°.
No fish taken.
Wall-eyed pike and eels recommended for planting.

Lincoln lake, Spencer township:
Length 2 miles, width $\frac{3}{4}$ mile; greatest depth 75 feet.
Shores high.
Bottom hard sand and gravel with some marl.
Inlet, one from Little Lincoln lake.
Outlet, one into Black river.
Date of examination, July 22.
Weather and water clear.
Temperature, surface 73°; bottom 42.
Fish taken, black bass, bluegills, perch, bullheads, and speckled bass.
The fish were in good condition and large.
Would recommend wall-eyed pike and eels for future planting.

Pickerel lake, Plainfield township:
Length $\frac{3}{4}$ mile, width $\frac{1}{2}$ mile; greatest depth 28 feet.
Shores high except on south and southeast sides; sand beach.
Bottom sand and marl.
Inlet, one from Clear lake.
Oulet, one into Rogue river.
Date of examination, June 26.
Weather and water clear.
Temperature, surface 78°; bottom 72.°
No fish taken.
No recommend as to planting.

Island lake, Plainfield township:
Length $\frac{3}{4}$ mile, width $\frac{1}{2}$ mile; greatest depth 60 feet.
Shores mostly high with sand beach.
Bottom marl and sand.
No inlet.
Outlet, one into Rogue river.
Dates of examination, June 25, 26 and 27.
Weather and water clear.
Temperature, surface 80°; bottom 42°.
Fish taken, perch, bluegills, mud bass, black bass and bullheads.
The perch were large, and all fish were fat and in good condition.
Wall-eyed pike recommended for future planting.

Camp lake, Algoma township:
Length $1\frac{1}{4}$ miles, width $\frac{1}{3}$ mile; greatest depth 55 feet.
Shores high sand beach except on north side which is muddy.
Bottom sand.
No inlet.
Outlet, one flowing into Rogue river.
Dates of examination, June 26 and 27.
Weather and water clear.
Temperature, surface 79°; bottom 46°.
Fish taken, perch, bluegills, black bass, and speckled bass.
Fish were in good condition and large.
Wall-eyed pike recommended for future planting.

Camel lake, Caledonia township:
Length $\frac{3}{4}$ mile, width $\frac{1}{2}$ mile; greatest depth 68 feet.
Shores high on north and west sides, with sand beach; low and swampy on south and east.
Bottom hard gravel and marl.
No inlet.
Outlet one small one, which is dried up at present.
Date of examination, June 29.
Weather and water clear.
Temperature, surface 74°; bottom 40°.
No fish taken.
Wall-eyed pike and eels recommended for future planting.

Camp lake, Caledonia township:
Length 1 mile, width $\frac{1}{2}$ mile; greatest depth 60 feet.
Shores high and timbered on west side, low and marshy on east side, with sand beach.
Bottom marl and mud.
No inlet.
Outlet, one into Thornapple river.
Dates of examination, June 29 and 30.
Weather clear, water muddy.
Temperature, surface 74°; bottom 45°.
Fish taken, perch, bluegills and suckers.
The fish were in good condition and large.
Wall-eyed pike and eels recommended for future planting.

Fisk lake, Grand Rapids township:
Length $\frac{1}{2}$ mile, width $\frac{1}{3}$ mile; greatest depth 61 feet.
Shores high on north and west sides; balance mostly low and muddy.
Bottom, clay, sand, marl and mud.
Inlet, one from Reed lake.
Outlet, one into Grand river.
Date of examination, June 30.
Weather and water clear.
Temperature, surface 70°; bottom 45°.
No fish taken.
Wall-eyed pike and eels recommended for future planting.

Pratt lake, Lowell township:
Length 1 mile, width $\frac{1}{2}$ mile; greatest depth 14 feet.
Shores high on north side; low and marshy on south side.
Bottom, muddy and soft.
No inlet or outlet.
Date of examination, June 30.
Temperature, surface 76°; bottom 68°.
Weather clear, water cloudy and dark.
No fish taken.
No recommendation as to future planting.

Reed lake, Grand Rapids township:
Length $1\frac{3}{4}$ miles, width $\frac{3}{4}$ miles; greatest depth 60 feet.
Shores high bluff on north and south sides; low on east and west.
Bottom, marl, sand and mud.
Inlet, one small stream on the east.
Outlet, one into Fisk lake.
Dates of examination, June 28, 29, 30 and July 1.
Weather clear except on July 1 when it was cloudy.
Water clear.
Temperature, surface 72°; bottom 55°.
Fish taken, pickerel, perch, sunfish, black bass, bluegills, dogfish, bullheads and speckled bass.
The fish were in good condition, large and fat.
Wall-eyed pike and eels recommended for future planting.

Powers or Twin lake, Grand Rapids township:
Length $\frac{1}{2}$ mile, width $\frac{1}{3}$ mile; greatest depth 75 feet.
Shores high and clear, sand beach.
Bottom sand and marl.
No inlet or outlet.
Date of examination, July 3.
Weather and water clear.
Temperature not taken.
No fish taken.
Wall-eyed pike recommended for future planting.

Bostwick lake, Cannon township:
Length 1 mile, width $\frac{3}{4}$ mile; greatest depth 25 feet.
Shores high, sand and gravel.
Bottom sand.

No inlet or outlet.
Date of examination, July 11.
Weather and water clear.
Temperature, surface 71°; bottom 68°.
No fish taken and no recommend as to planting.

Crooked lake, Grattan township:
Length 1½ miles, width ¼ mile; greatest depth 40 feet.
Shores high except on north side which is low and marshy, beach soft and muddy, except on east and south side, which is sandy.
Bottom soft and muddy.
Inlet, one from Round lake.
Outlet, one small stream into Seely creek.
Dates of examination, July 9, 10 and 11.
Weather clear, water roily.
Temperature, surface 71°; bottom 50°.
Fish taken, black bass, perch, bluegills, sunfish and bullheads.
The fish were small but in good condition.
Eels recommended for future planting.

Slayton lake, Grattan township:
Length ¾ mile, width ¼ mile.
Shores high and wooded, sand and gravel beach.
Bottom hard sand and marl.
Inlet, one small stream.
Outlet, one into Seeley creek.
Date of examination, July 10 and 11.
Weather and water clear.
Temperature, surface 73°; bottom 45°.
Fish taken, bluegills, sunfish and perch.
The fish were in good condition.
No recommend as to planting.

Silver lake, Cannon township:
Length 1 mile, width ¾ mile; greatest depth 40 feet.
Shores high, sand and marl beach.
Bottom, sand and gravel.
Inlet, one small stream on each side.
No outlet.
Dates of examination, July 11 and 12.
Weather and water clear.
Temperature, surface 74°; bottom 63°.
Fish taken, black bass, black suckers, bluegills, perch, sunfish and speckled bass.
The fish were in good condition and showed good growth.
No recommend as to planting.

Nagle, Big, or Horse Shoe lake, Grattan township:
Length 1¾ miles, width ½ mile; greatest depth 78 feet.
Shores mostly high and timbered; beach, soft except on east side.
Bottom, sand and marl.
Inlet, one.
Outlet, one into Flat river.

Date of examination, July 11, 12 and 13.
Weather and water clear.
Temperature, surface 73°; bottom 43°.
Fish taken, black bass, perch, bluegills, sunfish, bullheads and pickerel.
The fish were in good condition and large.
Wall-eyed pike recommended for future planting.

Round lake, Grattan township:
Length $\frac{3}{4}$ mile, width $\frac{1}{2}$ mile; greatest depth 90 feet.
Shores high with sand beach.
Bottom hard sand and marl.
Inlets, two small streams.
Outlet, one into Crooked lake.
Date of examination, July 13.
Weather and water clear.
Temperature, surface 73°; bottom 43°.
Fish taken, pickerel, bluegills, sunfish, bullheads, speckled bass and black bass.
Fish in good condition, hard and showed good growth.
Wall-eyed pike recommended for future planting.

LAPEER COUNTY.

Nipissing lake, Elba township:
Length 1 mile, width $\frac{1}{2}$ mile; greatest depth 24 feet.
Shores high with sand beach.
Bottom soft and muddy.
No inlet or outlet.
Dates of examination, August 12, 13 and 14.
Weather clear, water roily.
Temperature, surface 77°; bottom 71°.
Fish taken, black bass, pickerel, bluegills, perch, sunfish, gar pike, dogfish and speckled bass.
The fish were hard and in good condition; feeding on crustaceans.
Eels recommended for future planting.

MONTCALM COUNTY.

Crooked lake, Evergreen township:
Length $\frac{3}{4}$ mile, width $\frac{1}{4}$ mile; greatest depth 27 feet.
Shores high on east and south, low on north and west, low, muddy beach.
Bottom soft and muddy.
No inlet or outlet.
Date of examination, August 24.
Weather cloudy and rainy, water cloudy.
No fish taken, and no recommend as to planting.

Loon lake, Evergreen and Crystal townships:
Length $\frac{3}{4}$ miles, width $\frac{3}{4}$ mile; greatest depth 21 feet.
Shores high with a sand beach.
Bottom soft and muddy.
No inlet or outlet.

Date of examination, Aug. 25.
Weather clear, water cloudy.
Temperature, surface 72°; bottom 61°.
No fish taken and no recommendation for planting.

Crystal lake, Crystal Lake township:
Length 1½ miles, width 1 mile; greatest depth 60 feet.
Shores high and wooded; sand and gravel beach.
Bottom hard sand and marl.
Inlet, one small stream.
Outlet, one large stream into Fish creek.
Dates of examination, Aug. 24, 25 and 26.
Weather, 24th, clear; 25th, rain; 26th, cloudy.
Water clear.
Temperature, surface 77°; bottom 49°.
Fish taken, pickerel, small mouth black bass, large mouth black bass, bluegills, perch and sunfish.
The fish were in good condition, large and fat.
Wall-eyed pike and eels recommended for future planting.

Bass lake, Richland township:
Length ¾ mile, width 100 rods; greatest depth 11 feet.
Shores low, with muddy beach.
No inlet or outlet.
Date of examination, Aug. 26.
Weather cloudy, water roily.
Temperature, surface 70°; bottom 64°.
No fish taken, and no recommendation as to planting.

Duck lake, Crystal township:
Length one mile, width ¾ mile; greatest depth 15 feet.
Shores low, with sand and muddy beach.
Bottom mostly muddy, some sand.
No inlet.
Outlet, one flowing into Fish creek.
Date of examination, Aug. 26.
Weather cloudy, water roily.
Temperature, surface 73°; bottom 64°.
No fish taken and no recommend as to planting.

Dickerson's lake, Douglass and Sidney townships:
Length 1 mile, width ½ mile; greatest depth 37 feet.
Shores high on north and south sides; low on east and west, with sand and muddy beach.
Bottom soft and muddy.
Inlet, one small stream.
Outlet, one flowing into Flat river.
Date of examination, August 29.
Weather clear, water cloudy.
Temperature, surface 76°; bottom 54°.
No fish taken, and no recommend as to future planting.

Big and Little Turk lake, Montcalm township:
Length $1\frac{1}{2}$ miles, width $\frac{1}{2}$ mile; greatest depth 18 feet.
Shores high on west side, low and marshy on east side.
Bottom soft, mostly marl.
No inlet or outlet.
Temperature, surface 66°; bottom 60°.
No fish taken, and no recommend as to planting.

Clifford lake, Douglass township:
Length $1\frac{1}{4}$ miles, width $\frac{1}{4}$ mile; greatest depth 50 feet.
Shores high, with sand beach.
Bottom hard clay.
No inlet or outlet.
Dates of examination, August 28, 29 and 30.
Weather and water clear.
Temperature, surface 74°; bottom 56°.
Fish taken, black bass, perch, speckled bass, bluegills, sunfish and pickerel.
Fish in good condition and feeding on crustaceans.
Eels recommended for future planting.

Derby lake, Sidney township:
Length 1 mile, width $\frac{1}{2}$ mile; greatest depth 95 feet.
Shore high all around except on north east corner, mostly sand and gravel beach.
Bottom hard sand and clay.
No inlet.
Outlet, flowing to Fish creek.
Dates of examination, Aug. 29 and 30.
Temperature, surface 73°; bottom 42°.
Weather and water clear.
Fish taken, pickerel, black bass, speckled bass, bluegills, sunfish and perch.
Wall-eyed pike and eels recommended for future planting.

Baldwin lake, Eureka township:
Length 1 mile, width $\frac{1}{2}$ mile; greatest depth 34 feet.
Shores high and wooded; sand and gravel beach.
Bottom mostly sand, some soft mud.
No inlet.
Outlet, one flowing to Flat river.
Date of examination, Aug 31.
Weather cloudy, water clear.
Temperature, surface 65°; bottom 57°.
No fish taken.
Eels recommended for planting.

Long lake, Pine township:
Length 1 mile, width $\frac{1}{2}$ mile; greatest depth 17 feet.
Shores high, covered with dead pine, sand beach.
Bottom soft and muddy.
One inlet and no outlet.
Date of examination, Sept. 1.

Weather clear, water roily.
Temperature, surface 65°; bottom 64°.
No fish taken, and no recommend as to planting.

Muskallonge lake, Maple Valley township:
Length 1½ miles, width ¾ mile; greatest depth 37 feet.
Shores high and covered with dead pine.
Bottom soft marl and sand.
Inlet, one small stream.
Outlet, one, flowing to Lincoln lake.
Date of examination, Sept. 1.
Weather and water clear.
Temperature, surface 65°; bottom 52°.
No fish taken.
Wall-eyed pike and eels recommended for planting.

Cowden lake, Maple Valley township:
Length 1 mile, width ½ mile; greatest depth 42 feet.
Bottom hard and sandy.
No inlet or outlet.
Date of examination, Sept. 1.
Weather and water clear.
Temperature, surface 67°; bottom 57°.
No fish taken.
Wall-eyed pike recommended for planting.

Tamarack lake, Kato township:
Length 1¼ mile, width ¾ mile; greatest depth 20 feet.
Shores high, bottom covered with sawdust.
No inlet or outlet.
Date of examination, September 3.
Weather clear and cold, water dark and roily.
Temperature, surface 62°; bottom 60°.
No fish taken and no recommend as to planting.

Six lakes, Belvidere township:
Length lake No. 4, ½ mile, No. 5, ¾ mile; width, No. 4, 100 rods, No. 5, ½ mile; greatest depth 35 feet.
Shores high with sand beach.
Bottom mostly hard and sandy.
One inlet and one outlet.
Date of examination, September 3.
Weather clear and cold, water dark and cloudy.
No fish taken.
Eels recommended for future planting.

Town Line lake, Kato and Belvidere townships:
Length 1½ miles, width ½ mile; greatest depth 40 feet.
Shores high with sand beach; bottom covered with sawdust.
No inlet; outlet, one into Flat river.
Date of examination, September 3.
Weather and water clear.
Temperature, surface 65°; bottom 55°.
No fish taken and no recommend as to future planting.

OTTAWA AND MUSKEGON COUNTIES.

Spring lake, Spring lake and Fruit Port townships:
Length 5 miles, width ¾ mile; greatest depth 47 feet.
Shores high and sandy with sand beach.
Bottom clay, sand and gravel.
Inlets, five, five streams, also a number of springs along the shore.
Outlet, one which empties into Grand river.
Dates of examination, June 19, 20, 21 and 22.
Weather, 19 and 20, cloudy; 21 and 22, clear.
Water clear.
Temperature, surface 72°; bottom 62°.
Fish taken, wall-eyed pike, perch, bluegills, sunfish, bullheads, suckers, speckled bass, large mouth black bass, sheephead and rock bass.
The fish were all hard but small, except wall-eyed pike and sheephead which were large and fat.
No recommendation as to future planting.

OTTAWA COUNTY.

Black lake, Holland township:
Length 6 miles, width 2 miles; greatest depth 30 feet.
Shores high, with sand beach nearly around.
Bottom marl and sandy.
Inlets, eight, seven small and one large stream; outlets, one large stream into Lake Michigan.
Dates of examination, June 15, 16, 17 and 18.
Weather, 15 and 16, clear; 17 and 18, cloudy.
Water clear.
Temperature, surface 72°; bottom 60°.
Fish taken, herring, white bass, pickerel, perch, rock bass, black bass, speckled bass, bullheads, suckers, bluegills, sunfish, sheepheads and gar pike. The fish taken were in splendid condition, hard and fat, and stomachs full of different kinds of food.
Could recommend nothing but eels.

Crockery lake, Chester township:
Length 1 mile, width ⅓ mile; greatest depth 53 feet.
Shores high, sod growing to water's edge.
Bottom hard, marl and sand.
Inlets, two small streams, one on the east end and one on the southwest side; outlet, one on west end flowing into Crockery creek.
Date of examination, June 23.
Weather and water clear.
Temperature, surface 75°; bottom 45°.
No fish taken.
Wall-eyed pike and white bass recommended for future planting.

Finnessey lake, Talmadge township:
Length ¾ mile, width ¼ mile; greatest depth 10 feet.
Shores mostly low and muddy, high on the north side, with sand beach.
Bottom soft and muddy.

No inlet or outlet.
Date of examination, July 1.
Weather and water clear.
Temperature, surface 74°; bottom 73°.
No fish taken and no recommend as to future planting.

EXAMINATION OF LAKES, 1892.

MECOSTA COUNTY.

Young's lake, Grant township:
Length $\frac{3}{4}$ mile, width $\frac{1}{2}$ mile; greatest depth 20 feet.
Shores high on north and west side, low and marshy on the east and south side.
Bottom soft, on the east and south side, hard clay on west side.
Inlets, none.
Outlet, one, flowing into Muskegon river.
Date of examination, September 15.
Weather clear, water dark.
Temperature, surface 62°; bottom 60°.
No fish taken.
Eels recommended for future planting.

Foger lake, Chippewa township:
Length $\frac{3}{4}$ mile, width 60 rods; greatest depth 48 feet.
Shore mostly low, with muddy beach, except north side, which is high, with sand beach.
Bottom sand on north and east, balance muddy.
No inlet or outlet.
Date of examination, Sept. 16.
Weather clear, water dark.
Temperature, surface 61°; bottom 51°.
No fish taken.
Eels recommended for future planting.

Pickerel lake, Grant and Coalpacks townships:
Length $\frac{1}{2}$ mile, width $\frac{1}{2}$ mile; greatest depth 43 feet.
Shores high, except on northeast side, which is low and marshy; beach all soft, except on southeast side.
Bottom, mostly mud, some clay.
One inlet and one outlet.
Date of examination, Sept. 17.
Weather clear, water dark.
No fish taken.
Eels recommended for future planting.

Town Line lake, Big Rapids and Coalpacks townships:
Length $\frac{1}{2}$ mile, width $\frac{1}{2}$ mile; greatest depth 50 feet.
Shores mostly high with sand beach.
Bottom soft and muddy.
Inlets, two small streams; outlet, one flowing into Muskegon river.
Date of examination, Sept. 17.

Weather and water clear.
Temperature, surface 67°; bottom 46°.
No fish taken.
Wall-eyed pike and eels recommended for future planting.

Round lake, Martiny township:
Length 1 mile, width ¾ mile; greatest depth 8 feet.
Bottom mud.
No inlet.
Outlet, one into Horsehead lake.
Date of examination, Sept. 19.
Weather clear, water dark.
Temperature, surface 62°; bottom 61°.
No fish taken, and no recommend as to future planting.

Horsehead lake, Martiny township:
Length 2 miles, width 1 mile; greatest depth 54 feet.
Shores high, with sand and gravel beach.
Bottom clay, gravel, marl and mud.
Inlet, one.
Outlet, one, flowing into Little Muskegon river.
Dates of examination, Sept. 19 and 20.
Weather clear, water dark.
Temperature, surface 63°; bottom 54°.
Fish taken, grass pike, rock bass, sunfish and bullhead.
The fish were in good condition, but small; feeding on larva and vegetation.
Wall-eyed pike recommended for future planting.

Evans lake, Chippewa and Martiny townships:
Length 1½ mile, width ¾ mile; greatest depth 49 feet.
Shores mostly low with soft, muddy beach.
Bottom, clay marl and mud.
Inlet, one; outlet, one flowing to Chippewa river.
Date of examination, September 20.
Weather clear, water dark.
Temperature, surface 62°; bottom 48°.
Fish taken, grass pike, large mouth black bass, rock bass, bluegills and perch.
Wall-eyed pike and eels recommended for future planting.

Clear lake, Martiny and Sheridan townships:
Length ½ mile, width ½ mile; greatest depth 25 feet.
Shores high all round except on west side which is low, mostly sand beach.
Bottom hard near shore, muddy in center.
Inlet, one; outlet, one flowing into Chippewa river.
Date of examination, September 20.
Weather and water clear.
Temperature, surface 63°; bottom 61°.
No fish taken. Eels recommended for future planting.

Chippewa lake, Chippewa township:
Length $1\frac{3}{4}$ miles, width $1\frac{1}{4}$ miles; greatest depth 38 feet.
Shores mostly high, with sand beach.
Bottom hard clay.
Inlets, two small streams.
Outlet, one, flowing into Chippewa river.
Dates of examination, September 15, 16, 17, 18, 19, 20, 21.
Weather clear, water dark.
Temperature, surface 63°; bottom 61°.
Fish taken, small mouth black bass, grass pike, calico bass, rock bass, bluegills, perch, suckers and dogfish.
The fish taken were in fair condition, not very large, feeding principally on larva.
Eels recommended for future planting.

Round lake, Morton township:
Length 1 mile, width $\frac{3}{4}$ mile; greatest depth 43 feet.
Shores mostly high, with sand beach.
Bottom marl and sandy.
Inlet, one.
Outlet, one, flowing to Long lake.
Dates of examination, September 21 and 22.
Weather and water, clear.
Temperature, surface 65°; bottom 49°.
Fish taken, grass pike, bluegills, sunfish, and perch.
The fish taken were in good condition, feeding on larva, crustacea and vegetation.
Eels recommended for future planting.

Long lake, Morton township:
Length $1\frac{1}{2}$ mile, width $\frac{1}{2}$ mile; greatest depth 47 feet.
Shores mostly high, with sand beach; low and swampy on east side.
Bottom, hard clay and marl.
Inlet, one.
Outlet, one flowing into Little Muskegon river.
Dates of examination, September 21 and 22.
Weather and water clear.
Fish taken, perch, grass pike, bullheads, bluegills and rock bass.
The fish were small, but in good condition, feeding on larva and vegetation.
Eels recommended for future planting.

Blue lake, Morton township:
Length 1 mile, width $\frac{3}{4}$ mile; greatest depth 50 feet.
Shores high all around, except on west side, sand beach.
Bottom clay and marl.
Inlet, one; outlet, one flowing into Little Muskegon river.
Dates of examination, Sept. 22 and 23.
Weather and water clear.
Temperature, surface 62°; bottom 52°.
Fish taken, grass pike, large mouth black bass, bluegills, bullheads, and perch.

The fish taken were in good condition, hard and fat, feeding on shells and vegetation.
Wall-eyed pike and small mouth bass recommended for future planting.

MUSKEGON COUNTY.

Wolf lake, Egelston township:
Length 1 mile, width 1 mile; greatest depth 42 feet.
Shores high, with sand beach all around.
Bottom around central part, muddy; balance sand.
Inlet, one small stream; no outlet.
Dates of examination, July 22, 23, 24.
Weather and water clear.
Temperature, surface 77°; bottom 63°.
Fish taken, large mouth black bass, bluegills, perch, bullheads, and dogfish.
Fish were large, fat and hard, and in good condition.
Wall-eyed pike recommended for future planting.

Little Black lake, Norton township:
Length $\frac{3}{4}$ mile, width 100 rods; greatest depth 14 feet.
Shores low, with sand beach.
Bottom soft and muddy.
Inlet, one small stream.
Outlet, one, emptying into Lake Michigan.
Date of examination, July 26.
Weather clear, water very dark.
Temperature, surface 86°; bottom 84°.
No fish taken and no recommend as to future planting.

Mona or Black lake, Martin township:
Length 4 miles, width $\frac{1}{2}$ mile; greatest depth 50 feet.
Shores high, with mostly sand beach.
Bottom muddy.
Inlets, six, the principal one being Black creek.
Outlet, one, which empties into Lake Michigan.
Dates of examination, July 26, 27, 28 and 29.
Weather clear, water very dark.
Temperature, surface 87°; bottom 66°.
Fish taken, large mouth black bass, calico bass, bluegills, suckers and gar pike.
The fish taken were poor and small.
No recommend as to future planting.

Goose Egg lake, Dalton township:
Length $\frac{1}{2}$ mile, width 40 rods; greatest depth 12 feet.
Shores high all round with sand beach.
Bottom mud, weeds all over the lake showing above the surface.
No inlet or outlet.
Date of examination, August 1.
Weather clear, water very dark.
Temperature, surface 72°; bottom 70°.
No fish taken and no recommendation as to planting.

Fox lake, Dalton township:
Length ¾ mile, width 60 rods; greatest depth 12 feet.
Shores high with sand beach all around.
Bottom soft mud.
No inlet or outlet.
Date of examination, August 1.
Weather clear, water dark.
Temperature, surface 73°; bottom 70°.
No fish taken and no recommendation as to future planting.

Town Line lake, Cedar Creek township:
Length 80 rods, width 50 rods; greatest depth 8 feet.
Shores high oak openings, with sand beach.
Bottom soft mud.
No inlet or outlet.
Date of examination, August 2.
Temperature, surface 78°; bottom 75°.
No fish taken and no recommendation as to planting.

Duck lake, Cedar Creek township:
Length ½ mile, width ½ mile; greatest depth 24 feet.
Shores high with sand beach nearly all around.
Bottom soft and muddy.
Inlets, two and one outlet.
Date of examination, August 4.
Weather and water clear.
Temperature, surface 74°; bottom 66°.
No fish taken and no recommendation as to future planting.

Clear lake, Cedar Creek township:
Length ¾ mile, width 100 rods; greatest depth 46 feet.
Shores high with sand beach all around.
Bottom marl.
No inlet except springs.
Outlet, one flowing into Mud lake.
Dates of examination, August 2, 3 and 4.
Weather cloudy on 2d and 4th; clear on the 3d.
Water clear.
Temperature, surface 73°; bottom 52°.
Fish taken, pickerel, bluegills, bullheads, black bass, perch, calico bass and sunfish.
The fish were in good condition, of fair size and fat.
Eels recommended for future planting.

Twin lakes, Dalton township:
Length 1¾ miles, width ¾ mile; greatest depth 32 feet.
Shores high, with sand beach all around.
Bottom, east lake, mud and sand; middle lake, mud, clay and sand; north lake, mud and clay; west lake, clay, marl and sand.
No inlet or outlet.
These lakes were at one time all in one, but the water has lowered until there are now four separate lakes with sandbars between them.
Dates of examination, August 1, 2, 3 and 4.

Weather and water clear.
Temperature, surface 82°; bottom 72°.
Fish taken, perch, sunfish, bullheads and chub suckers.
The fish were in good condition, the perch very fat.
Eels recommended for future planting.

Lake on Sec. 30, no name, Holton township:
Length ½ mile, width 40 rods; greatest depth 6 feet.
Shores high on west side, low and marshy on east side.
Bottom soft and muddy.
No inlet or outlet.
Date of examination, August 5.
Weather clear, water dark.
Temperature, surface 73°; bottom 70°.
No fish taken and no recommendation as to planting.

Crooked lake, Holton township:
Length ¾ mile, width 100 rods; greatest depth 18 feet.
Shore high; bottom soft and muddy.
No inlet or outlet.
Date of examination, Aug. 5.
Weather clear, water dark.
Temperature, surface 78°; bottom 70.°
No fish taken and no recommendation as to planting.

Round lake, Holton township:
Length ½ mile, width 50 rods; greatest depth 6 feet.
Shores high all around; bottom soft mud.
No inlet or outlet.
Date of examination, Aug. 5.
Weather clear, water dark.
Temperature, surface 74°; bottom 71.°
No fish taken and no recommendation as to planting.

Big Blue lake, Blue Lake township:
Length 2½ miles, width ¾ mile; greatest depth 45 feet.
Shores high, with sand beach and oak timber all around.
Bottom hard marl and clay.
One inlet, and one outlet which flows into White river.
Date of examination, Aug. 6 and 7.
Weather and water clear.
Temperature, surface 74°; bottom 52.°
Fish taken, small and large mouth bass, perch, bluegills, suckers and golden shiners. The fish were in good condition, fat and hard; the small mouth bass weighed from 3 to 4½ pounds.
Wall-eyed pike and eels recommended for future planting.

Britton lake, Blue Lake township:
Length ½ mile, width 40 rods; greatest depth 22 feet.
Shores high with sand beach; bottom soft and muddy.
No inlet or outlet.
Date of examination, Aug. 8.
Weather cloudy, water dark.

Temperature, surface 78°; bottom 69°.
No fish taken and no recommendation as to future planting.

Round lake, Holton township:
Length 60 rods, width 40 rods; greatest depth 7 feet.
Shores high with sand beach; bottom soft and muddy.
No inlet or outlet.
Date of examination, Aug. 8.
Weather and water cloudy.
Temperature, surface 74°; bottom 72°.
No fish taken and no recommend as to future planting.

Little Blue lake, Blue Lake township:
Length 1 mile, width 80 rods; greatest depth 11 feet.
Shores high with sand beach; bottom very soft mud.
No inlet or outlet.
Date of examination, Aug. 8.
Weather cloudy, water clear.
Temperature, surface 79°; bottom 74°.
No fish taken, and no recommendation as to future planting.

Crystal lake, Blue Lake township:
Length 130 rods, width 80 rods; greatest depth 24 feet.
Shores high, with sand beach; bottom sandy and muddy.
No inlet or outlet.
Date of examination, Aug. 11.
Weather and water clear.
Temperature, surface 76°; bottom 69°.
No fish taken.
Eels recommended for future planting.

White lake, Fruit Land, White River, White Hall and Montague townships:
Length 5 miles, width $1\frac{1}{4}$ miles; greatest depth 80 feet.
Shores high, with sand beach.
Bottom covered with shingles and sawdust, some sand.
Inlets, six, the principal one being the White river.
Outlet, one which empties into Lake Michigan.
Date of examination, Aug. 10, 11, 12 and 13.
Weather clear, water dark.
Temperature, surface 74°; bottom 68°.
Fish taken, large and small mouth bass, white bass, perch, bluegills, calico bass, sheephead, redhorse, dogfish, and gar pike.
The fish taken were in good condition and feeding principally on crustaceans. Wall-eyed pike recommended for future planting.

Duck lake, Fruit Land township:
Length 2 miles, width $\frac{3}{4}$ mile; greatest depth 68 feet.
Shores high, with sand beach.
Bottom mostly hard clay and sand; soft and muddy on east end.
Inlet, one large stream called Duck creek.
Outlet, one, which empties into lake Michigan.
Dates of examination, Aug. 12, 13, 14.

Weather and water clear.
Temperature, surface 75°; bottom 55°.
Fish taken, small mouth bass, pickerel, herring, calico bass, bluegills, and gar pike.
The fish were in good condition and feeding principally upon larva.
Wall-eyed pike recommended for future planting.

MONTCALM COUNTY.

Bass lake, Pierson township:
Length 120 rods, width 100 rods; greatest depth 30 feet.
Shores high, with oak grubs and sand beach.
Bottom clay, sand and mud.
No inlet or outlet.
Dates of examination, July 29 and 30.
Weather and water clear.
Temperature, surface 71°; bottom 62°.
Fish taken, large and small mouth bass, bluegills and perch.
The fish were in good condition, the bluegills large and the bass and perch small, but fat.
Small mouth bass and eels recommended for future planting.

Whitefish lake, Pierson township:
Length 1½ miles, width 1 mile; greatest depth 50 feet.
Shores mostly high and partly cleared, sand beach.
Bottom mostly hard and sandy with some mud.
Three inlets and one outlet which empties into Little Whitefish lake.
Dates of examination, June 27, 28, 29, 30, July 1, 2 and 3.
Weather June 27 and July 2, rainy and cold; July 1 and 3 cloudy; June 28, 29 and 30, clear.
Water roily.
Temperature, surface 66°; bottom 56°.
Fish taken, herring, large mouth bass, pickerel, bluegills, perch, sunfish, bullheads, gar pike, mudfish, calico bass and rock bass.
The herring and gar pike were large and fat, the other fish small but in good condition.
Small mouth bass and eels recommended for future planting.

Little Whitefish lake, Pierson township:
Length ¾ mile, width ¾ mile; greatest depth 40 feet.
Shores northeast side high and clear, the balance low, swampy and timbered.
Bottom mostly marl, some sand.
Inlet, one large stream from Big Whitefish lake.
Outlet, Alley creek which empties into Tamarack creek.
Dates of examination, June 30, July 1 and 2.
Weather June 30 clear, July 1, cloudy, July 2, rainy and cold, water roily.
Temperature, surface 67°; bottom 53°.
Fish taken, pickerel, bluegills and perch.
The fish were in good condition, the bluegills and pickerel large, the perch small but fat.
Eels recommended for future planting.

Wood lake, Pierson township:
Length ½ mile, width 100 rods; greatest depth 35 feet.
Shores high, with sand beach; bottom muddy and sawdust.
No inlet or outlet.
Date of examination, July 3.
Weather cloudy, water roily.
Temperature, surface 66°; bottom 55°.
No fish taken and no recommendation as to future planting.

Sand lake, Pierson township:
Length ¾ mile, width ¾ mile; greatest depth 32 feet.
Shore high and mostly clear.
Bottom sand, mud and sawdust.
Inlet, none.
Outlet, Duke creek.
Date of examination, July 1.
Weather cloudy, water very roily.
Temperature, surface 68°; bottom 56°.
No fish taken and no recommendation as to future planting.

NEWAYGO COUNTY.

Horseshoe, or Baptist lake, Ensley township:
Length ½ mile, width ½ mile; greatest depth 62 feet.
Shores high and mostly cleared, with sand beach.
Bottom hard and sandy.
No inlet or outlet.
Dates of examination, July 2, 3, and 4.
Weather, July 2, rainy and cold; 3, cloudy and cold; 4, clear.
Water clear.
Temperature, surface 67°; bottom 59°.
Fish taken large mouth bass, bluegills and mud bass.
The fish were large and fat but soft.
Wall-eyed pike, small mouth bass and eels recommended for future planting.

Conover lake, Ensley township:
Length ½ mile, width 100 rods; greatest depth 75 feet.
Shores high mostly cleared, with sand beach.
Bottom hard sand.
No inlet or outlet.
Dates of examination, July 2, 3 and 4.
Weather July 2, rainy and cold; 3, cloudy and cold; 4, clear.
Water clear.
Temperature, surface 67°; bottom 42°.
Fish taken, large mouth bass, bluegills and perch.
The fish were in good condition, large and fat, feeding on shrimps and larva, the perch feeding on small fry.
Wall-eyed pike, small mouth bass and eels recommended for future planting.

Pettit lake, Croton township:
Length ¾ mile, width ½ mile; greatest depth 14 feet.

Shores mostly high with sand beach.
Bottom soft and very muddy.
No inlet or outlet.
Date of examination, July 8.
Weather clear, water dark.
Temperature, surface 77°; bottom 66°.
No fish taken.
Carp recommended for future planting.

Brooks lake, Brooks township:
Length $1\frac{1}{4}$ miles, width $\frac{3}{4}$ mile; greatest depth 15 feet.
Shores mostly high with sand beach.
Bottom sand and soft mud.
Inlet, one from Hess lake.
Outlet, one into Muskegon river.
Date of examination, July 8.
Weather clear, water dark.
No fish taken and no recommendation as to future planting.

Hess lake, Brooks township:
Length 3 miles, width not given; greatest depth not given.
Shores mostly high and sandy, low and marshy in places on the south side.
Bottom, sand along the north side, mud and marl along the south side.
Inlets, five, all on the south side.
Outlet, one into Brook's lake.
Dates of examination, July 7, 8 and 9.
Weather clear, water dark.
Temperature, surface 77°; bottom 66°.
Fish taken large mouth bass, bluegills, perch, sunfish, golden shiners and gar pike.
The fish were of good size and fat, but soft and wormy.
Nothing recommended for future planting.

Bills Lake, Croton township:
Length $\frac{3}{4}$ mile, width 100 rods; greatest depth 74 feet.
Shores high on the east side, low on the west side.
Bottom hard clay and marl, also some sand.
Inlet one, Spring brook.
Outlet the head of Rouge river.
Date of examination, July 8 and 9.
Weather and water clear.
Temperature, surface 76°; bottom 57°.
Fish taken, brook trout, small mouth bass, perch, bluegills, large mouth bass and sunfish.
The fish were large and fat.
Salmon trout, wall-eyed pike and small mouth black bass recommended for future planting.

Big Marl lake, Brooks and Everet townships:
Length $\frac{3}{4}$ mile, width 60 rods; greatest depth 58 feet.
Shores high, sand beach all around.
Bottom mostly clay and marl, with some mud.

No inlet.
One outlet which empties into Muskegon river.
Date of examination, July 11.
Weather and water clear.
Temperature, surface 76°; bottom 45°.
Fish taken, pickerel, large mouth bass, bluegills and perch.
Fish were in good condition, hard and fat.
Wall-eyed pike and small mouth bass recommended for future planting.

Kimbal lake, Garfield township:
Length 1 mile, width ½ mile; greatest depth 48 feet.
Shores high, sand beach on south and west side, balance mostly low and swampy.
Bottom mostly clay and marl and some mud.
One inlet and one outlet which empties into Pickerel lake.
Date of examination, July 11.
Weather cloudy, water clear.
Temperature, surface 77°; bottom 50°.
No fish taken.
Eels recommended for future planting.

Little Marl lake, Brooks township:
Length ½ mile, width 40 rods; greatest depth 35 feet.
Shores high, sand beach all around.
Bottom clay and marl.
Inlet one, from Big Marl lake.
Outlet one, flowing into Muskegon river.
Date of examination, July 11.
Weather and water clear.
Temperature, surface 80°; bottom 61°.
No fish taken.
Wall-eyed pike recommended for future planting.

Pickerel lake, Garfield township:
Length 1¼ miles, width ¾ mile; greatest depth 65 feet.
Shores mostly high with sand beach.
Bottom hard clay and sand.
Inlet one, from Kimbal lake.
Outlet one, into Muskegon river.
Dates of examination July 11 and 12.
Weather, 11th cloudy; 12th clear.
Water clear.
Temperature, surface 76°; bottom 49°.
Fish taken, pickerel, bluegills, perch, rock bass and black bass.
The fish were in good condition.
Wall-eyed pike and small mouth bass recommended for future planting.

Big Twin lake, Everett township:
Length ¾ mile, width 60 rods; greatest depth 23 feet.
Shores all high except on east side which is low and marshy.
Bottom clay, marl and mud.
Inlet one good sized stream.
Outlet one, which empties into Muskegon river.

Date of examination, July 12.
Weather and water clear.
Temperature, surface 77°; bottom 58°.
No fish taken and no recommendation as to future planting.

Fourth lake, Sherman township:
Length 80 rods, width 40 rods; greatest depth 20 feet.
Shores high and timbered on south side, low and swampy on north side.
Bottom muddy.
Inlet one from Peck's lake.
Outlet one into Third lake.
Date of examination, July 15.
Weather clear, water dark.
No fish taken and no recommendation as to future planting.

Third lake, Sherman township:
Length $\frac{3}{4}$ mile, width 100 rods; greatest depth 26 feet.
Shores soft and marshy all around. Pond lilies around entire lake.
Bottom soft and muddy.
Inlet, one from Fourth lake.
Outlet, one into Second lake.
Date of examination, July 15 and 16.
Weather clear, water dark.
Fish taken, bluegills and perch.
The fish were in fairly good condition.
No recommendation as to future planting.

Second lake, Sherman township:
Length 100 rods, width 60 rods; greatest depth 37 feet.
Shores mostly high, with soft, marshy beach. Pond lilies all around.
Bottom muddy.
Inlet, one from Third lake.
Outlet, one into First lake.
Date of examination, July 15.
Weather clear, water dark.
No fish taken and no recommendation as to future planting.

Peck's lake, Sherman township:
Length $\frac{1}{2}$ mile, width 60 rods; greatest depth 75 feet.
Shores high with sand beach on north side; low and muddy on south side.
Bottom soft and muddy.
No inlet.
Outlet, one into Fourth lake.
Dates of examination, July 17 and 18.
Weather and water clear.
Fish taken, calico bass, bluegills, perch and rock bass.
The fish were large and in good condition.
Wall-eyed pike recommended for future planting.

Crystal lake, Sherman township:
Length $\frac{1}{2}$ mile, width $\frac{1}{4}$ mile; greatest depth not given.
Shores high with sand beach all around.

Bottom hard clay.
No inlet or outlet.
Weather and water clear.
Temperature, surface 73°; bottom 51°.
Fish taken, large mouth bass, bluegills and perch.
The fish were in good condition, hard and fat.
Wall-eyed pike and small mouth bass recommended for future planting.

Big Bass lake, Sherman township:
Length $\frac{1}{2}$ mile, width 30 rods; greatest depth 38 feet.
Shores low and soft, partly sand beach.
Bottom soft and muddy.
Two inlets and one outlet which flows into White river.
Date of examination, July 19.
Weather clear, water very dark.
Temperature, surface 77°; bottom 55°.
No fish taken and no recommendation as to future planting.

Long lake, Sherman township:
Length $1\frac{3}{4}$ miles, width $\frac{3}{4}$ mile; greatest depth 90 feet.
Shores mostly high, with sand beach.
Bottom mostly hard, sand and gravel.
One inlet, and one outlet which flows into Kimbal lake.
Weather and water clear.
Temperature, surface 73°; bottom 43°.
Fish taken, pickerel, large mouth bass, bluegills, perch, calico bass, rock bass and bullheads.
The fish were hard and fat and feeding on larva and crustaceans.
Wall-eyed pike and small mouth bass recommended for future planting.

Fremont lake, Sheridan township:
Length $1\frac{1}{2}$ miles, width $1\frac{1}{4}$ miles; greatest depth 102 feet.
Shores high around, with sand beach.
Bottom mostly hard clay and sand.
Inlets, three; one large and two small streams.
Outlet one large stream flowing into Brook's creek.
Dates of examination, July 16, 17, 18 and 19.
Weather, 19th clear; 16th, 17th and 18th, cloudy.
Water clear.
Temperature, surface 77°; bottom 51°.
Fish taken, herring or ciscos, large mouth bass, pickerel, bluegills, calico bass, perch, rock bass, suckers, sunfish, bullheads and golden shiners.
Fish were in good condition, large and fat.
Wall-eyed pike, small mouth bass and salmon trout recommended for future planting.

Kims lake, Denver township:
Length 100 rods, width $\frac{1}{4}$ mile; greatest depth 20 feet.
Shores low and marshy nearly all around, except on north side; beach low and soft.
Bottom soft and muddy.
No inlet.

Outlet, one which flows into White river.
Date of examination, Aug. 31.
Weather cloudy and rainy, water dark.
Temperature, surface 76°; bottom 72°.
No fish taken and no recommendation as to future planting.

Little Twin lake, township has no name:
Length $\frac{3}{4}$ mile, width 60 rods; greatest depth 20 feet.
Shores high on north and west side, balance low and marshy.
Bottom soft and muddy and covered with weeds.
Inlet, one from Big Twin lake.
Outlet, one into Pickerel lake.
Date of examination, Sept. 6.
Temperature, surface 67°; bottom 64°.
No fish taken and no recommendation as to future planting.

Big Twin lake, township no name:
Length $\frac{1}{2}$ mile, width $\frac{1}{4}$ mile; greatest depth 56 feet.
Shores high on east and north sides with sand beach, balance low and marshy, beach soft.
Bottom marl and mud.
One inlet and one outlet which flows into Little Twin lake.
Dates of examination, Sept. 6 and 7.
Temperature, surface 68°; bottom 44°.
Weather and water clear.
Fish taken, grass pike, bluegills, and suckers.
Fish were in good condition, large, hard and fat, and feeding principally on crustacea.
Wall-eyed pike and eels recommended for future planting.

Pickerel lake, Barton township:
Length $\frac{3}{4}$ mile, width $\frac{1}{2}$ mile; greatest depth 45 feet.
Shores high on the east and west side, with sandy beach; balance low and muddy.
Bottom hard clay and marl on east side, balance soft and muddy.
Inlet, one large stream from Twin lake.
Outlet, one flowing into Pere Marquette river.
Dates of examination, Sept. 7 and 8.
Weather, 7th clear, 8th cloudy.
Water clear.
Temperatue, surface 66°; bottom 49°.
Fish taken, bluegills, suckers, golden shiners, and bullheads.
The fish were in good condition, large and fat.
Wall-eyed pike and eels recommended for future planting.

Diamond lake, Lincoln township:
Length $1\frac{1}{2}$ mile, width $\frac{1}{2}$ mile; greatest depth 35 feet.
Shores high with sand beach, except on west side, which is low, soft and muddy beach.
Bottom hard clay except on north end which is soft and muddy.
No inlet or outlet.
Dates of examination, Sept. 8 and 9.
Weather clear, water dark and muddy.

Temperature, surface 64°; bottom 59°.
Fish taken, perch, bluegills and bullheads.
The perch were large and fat and in good condition, other fish small.
Eels recommended for future planting.

Blue lake, Monroe township:
Length ½ mile, width ½ mile; greatest depth 15 feet.
Shores high on east side, with sand beach, bottom low and muddy.
Bottom soft mud.
No inlet or outlet.
Date of examination, Sept. 10.
Weather cloudy and rainy, water dark and muddy.
No fish taken and no recommendation as to future planting.

Crooked lake, Beaver and Monroe townships:
Length 2 miles, width ¾ miles; greatest depth 55 feet.
Shores high with sand beach nearly all around.
Bottom sand, marl and mud.
Inlet, one small stream.
Outlet, one which flows into Beaver lake.
Dates of examination, Sept. 10, 11 and 12.
Weather cloudy, water clear.
Temperature, surface 66°; bottom 48°.
Fish taken, pickerel, bluegills, perch, bullheads and large mouth bass.
The fish were in good condition, fair size and hard, feeding principally on crustacea.
Wall-eyed pike and eels recommended for future planting.

Blue lake, Troy township:
Length ½ mile, width ¼ mile; greatest depth not given.
Shores high with sand beach, botton soft and muddy.
No inlet or outlet.
Date of examination, Sept. 12.
Weather cloudy, water dark.
Temperature, surface 65°; bottom 61°.
No fish taken and no recommendation as to future planting.

Bass lake, Beaver and Troy townships:
Length 1 mile, width ½ mile; greatest depth 75 feet.
Shores high and wooded, with sand beach.
Bottom hard clay and sand.
No inlet or outlet.
Dates of examination, Sept. 12 and 13.
Weather cloudy, water clear.
Temperature, surface 66°; bottom 49°.
Fish taken, herring, perch and bluegills.
The fish were large and in good condition.
Wall-eyed pike and eels recommended for future planting.

OCEANA COUNTY.

Park's lake, Clay Banks township:
Length 100 rods, width 40 rods; greatest depth 12 feet.
Shores high with sand beach, except on west end which is low and muddy.
Bottom soft and muddy.
No inlet or outlet.
Date of examination, August 18.
Weather clear, water dark and muddy.
Temperature, surface 75°; bottom 72°.
No fish taken and no recommendation as to future planting.

Crystal lake, Heart township:
Length $\frac{3}{4}$ mile, width 100 rods; greatest depth 32 feet.
Shores hard with sand beach.
Bottom hard and sandy except on west end, which is sandy.
No inlet or outlet.
Date of examination, August 19.
Weather and water clear.
Temperature, surface 75°; bottom 58°.
No fish taken and no recommendation as to future planting.

AuSable or Silver lake, Golden township:
Length $1\frac{1}{2}$ miles, width 1 mile; greatest depth 21 feet.
Shores high, with sand beach on north and west side, low and marshy on south side.
Bottom sandy.
One inlet, and one outlet which empties into lake Michigan.
Date of examination, Aug. 22.
Weather cloudy, water clear.
Temperature, surface 75°; bottom 73°.
No fish taken and no recommendation as to future planting.

Stony lake, Benona township:
Length 3 miles, width $\frac{1}{2}$ mile; greatest depth 55 feet.
Shores high, with sand beach.
Bottom mostly hard sand, muddy on east end.
Inlets, two from Stony creek.
Outlet, one which empties into Lake Michigan.
Dates of examination, Aug. 18, 19, 20, 21, 22 and 23.
Weather, 18, 19, 20 and 21, clear; 22 and 23, cloudy and rainy.
Water clear.
Temperature, surface 78°; bottom 53°.
Fish taken, large and small mouth black bass, calico bass, pickerel and bluegills.
The fish were in good condition, large and fat, feeding on larva of flies and vegetation.
Wall-eyed pike recommended for future planting.

Campbell lake, Leavitt township:
Length 1 mile, width $\frac{1}{2}$ mile; greatest depth not given.

Shores mostly high and wooded, low on north and southwest side, partly sand beach.
Bottom soft and muddy.
No inlet.
Outlet, one large stream, Beaver creek, which flows to Pere Marquette river.
Dates of examination, Aug. 29 and 30.
Weather, 29, clear; 30, cloudy and rainy. Water clear.
Temperature, surface 72°; bottom 51°.
Fish taken, calico bass, bluegills, sunfish, rock bass and bullheads.
The fish were in fair condition, feeding principally on small crustacea.
Eels recommended for future planting.

Mud or Cob-moo-sa lake, Leavitt township:
Length ½ mile, width 60 rods; greatest depth 12 feet.
Shores high, with soft, muddy beach.
Bottom muddy.
No inlet or outlet.
Weather cloudy and rainy, water dark.
No fish taken and no recommendation as to future planting.

McLarens lake, Newfield township:
Length 1½ miles, width, ¾ mile; greatest depth 80 feet.
Shores mostly low, some high places, with soft, muddy beach all around.
Bottom mostly clay and marl, some mud.
Inlet, four small spring brooks.
Outlet, one large stream flowing into White river.
Dates of examination, Aug. 28, 29, 30 and 31, Sept. 1 and 2.
Weather, Aug. 27, 28 and 29, Sept. 1 and 2, clear; Aug. 30 and 31, cloudy, with rain.
Water clear.
Temperature, surface 75°; bottom 46°.
Fish taken, large mouth bass, rock bass, perch, bluegills, sunfish, bullheads and pickerel.
The fish were of fair size and good, except the perch which were wormy.
Wall-eyed pike recommended for future planting.

Gilbert lake, Leavitt township:
Length ¾ mile, width ½ mile; greatest depth 15 feet.
Shores high, with sand beach on south side, balance low and marshy with muddy beach.
Bottom soft mud.
No inlet.
Outlet, one which flows into Pere Marquette river.
Date of examination, Sept. 2.
Weather and water clear.
No fish taken and no recommendation as to future planting.

School Section lake, Colfax township:
Length ½ mile, width ⅓ mile; greatest depth 25 feet.
Shores high on north and east sides, low and marshy on west side, with sand beach all around.

Bottom soft and muddy.
Inlet, none.
Outlet, one, which flows to Pere Marquette river.
Date of examination, Sept. 1.
Weather and water clear.
Temperature, surface 72°; bottom 65°.
No fish taken and no recommendation as to future planting.

J. C. PARKER,
HERSCHEL WHITAKER,
HOYT POST.

THE RIPE EGGS AND THE SPERMATOZOA

OF THE

WALL-EYED PIKE

AND

THEIR HISTORY UNTIL SEGMENTATION BEGINS

BY

JACOB REIGHARD

Professor of Animal Morphology in the University of Michigan

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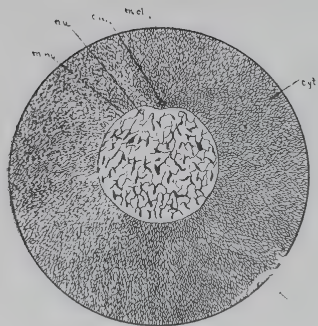

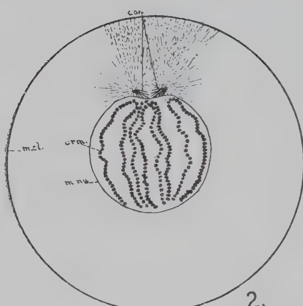

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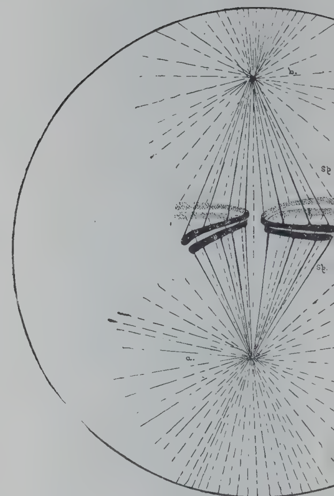

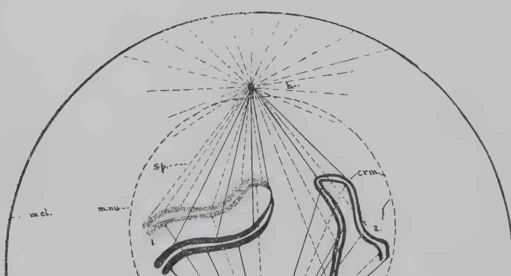

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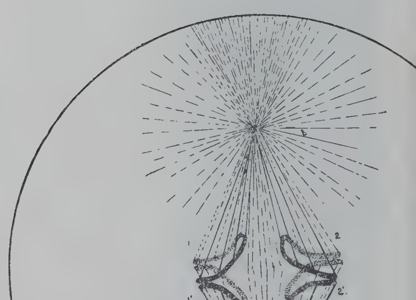

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PLATE I.

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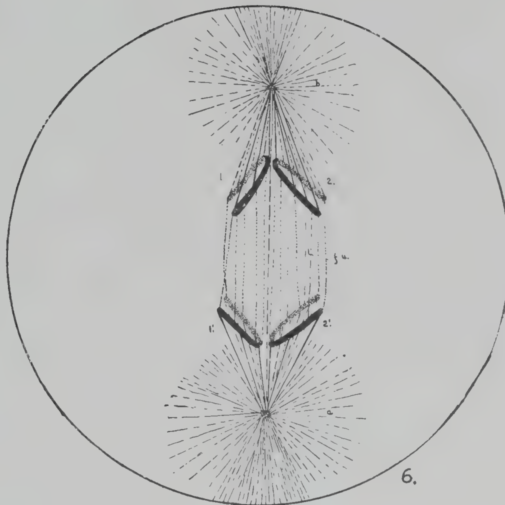

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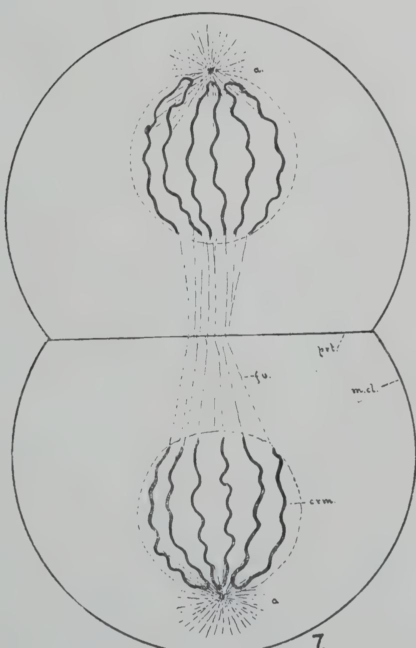

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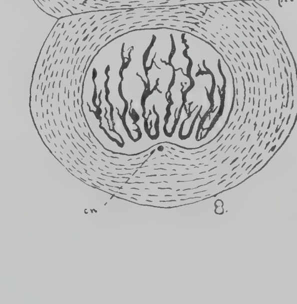

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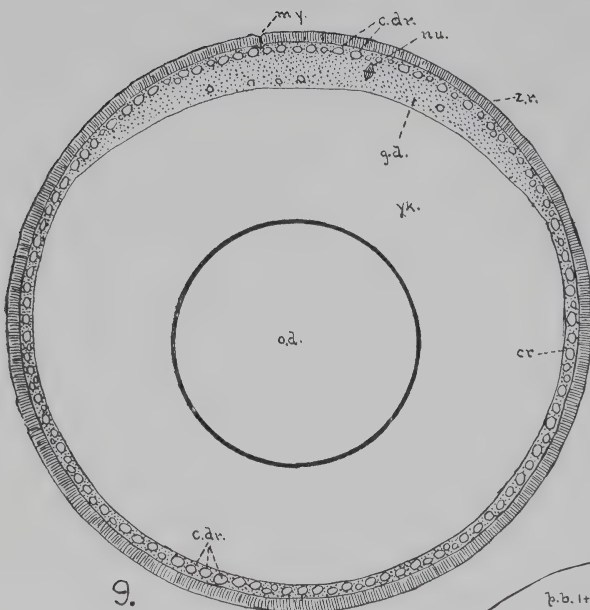
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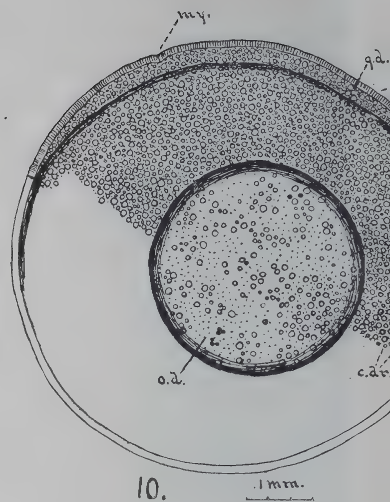
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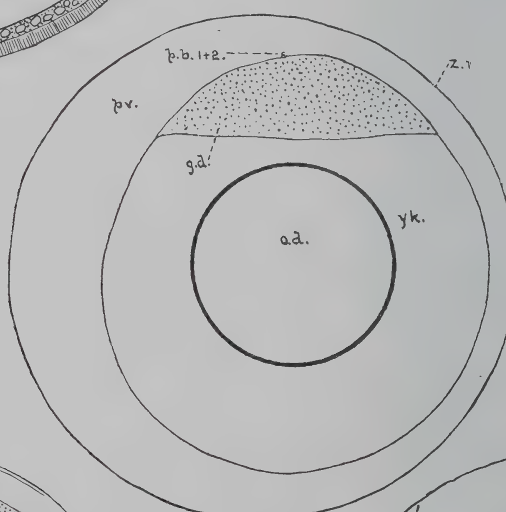
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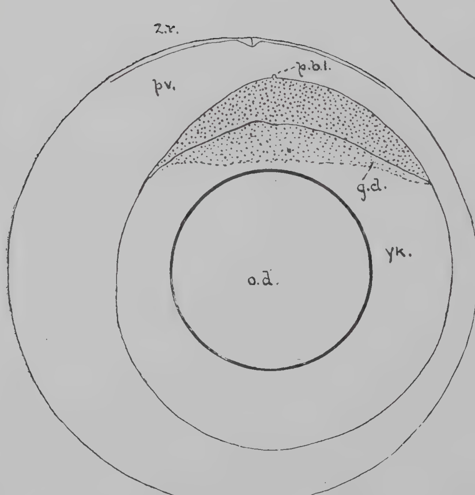
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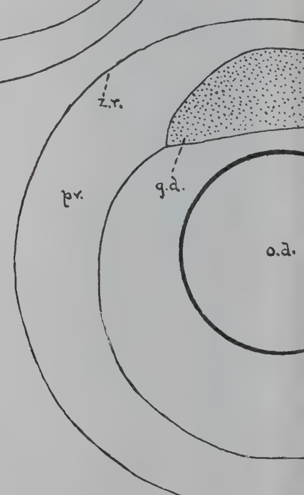
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PLATE II.

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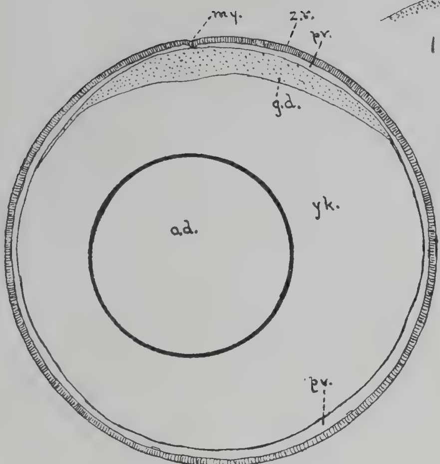

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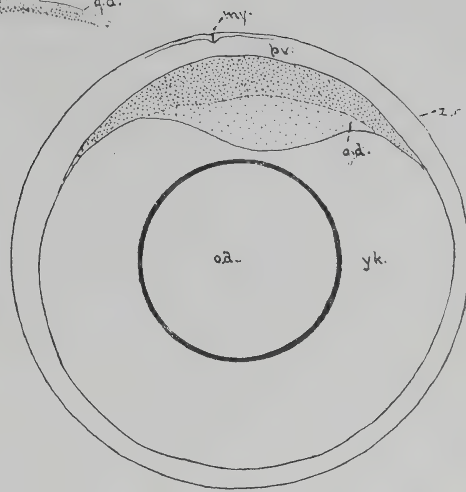

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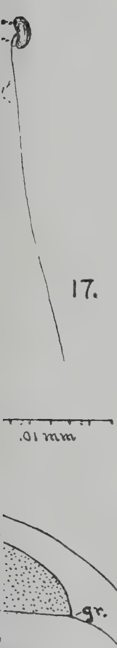

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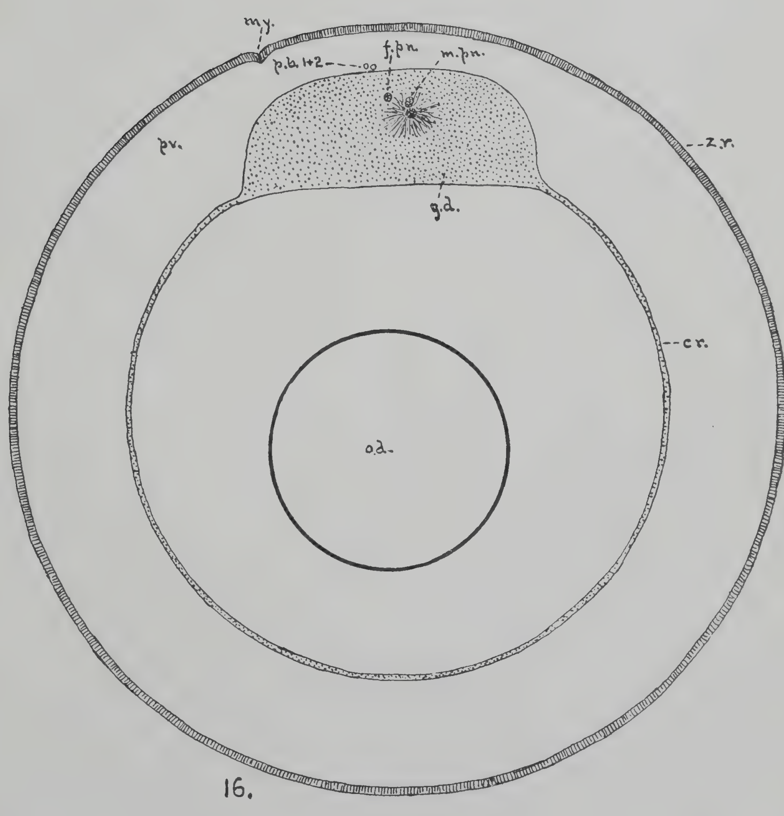

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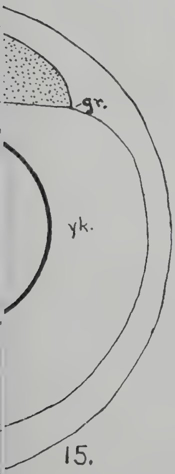

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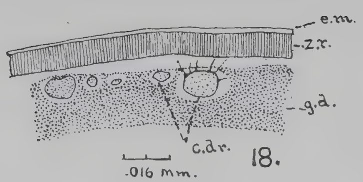

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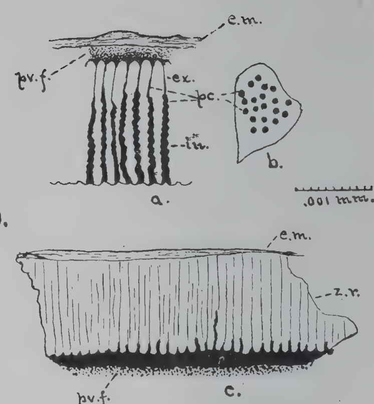

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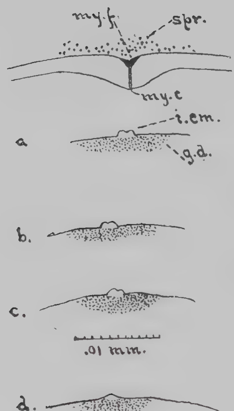

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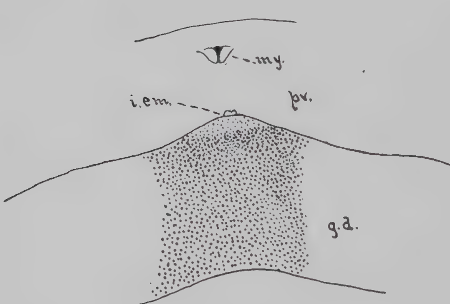

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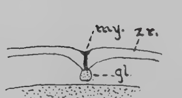

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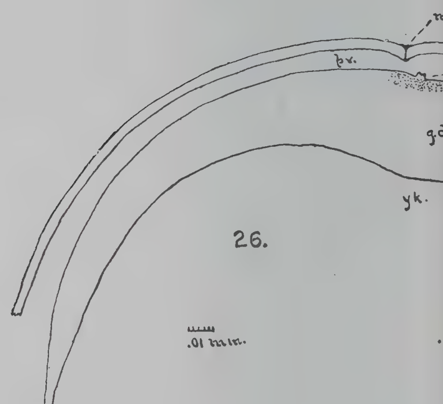

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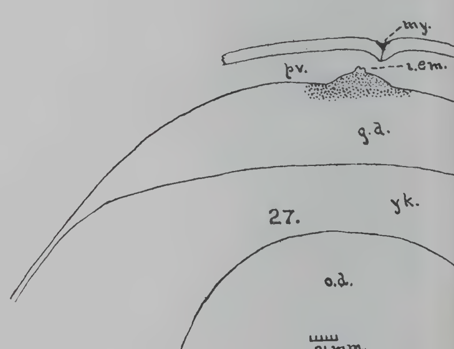
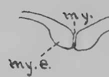


27.

J. E. Reighard del.

PLATE III.



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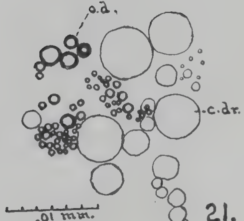

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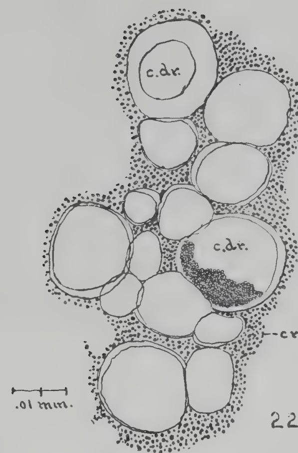

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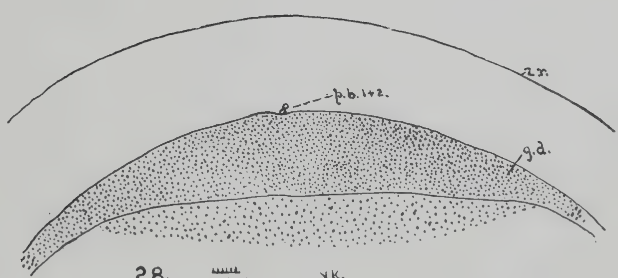

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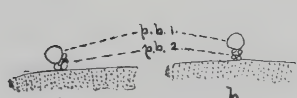

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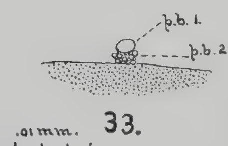

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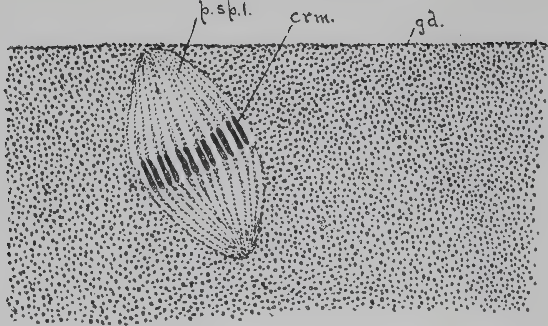

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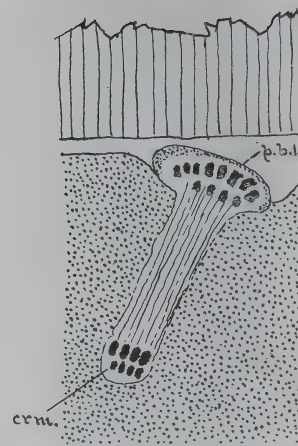

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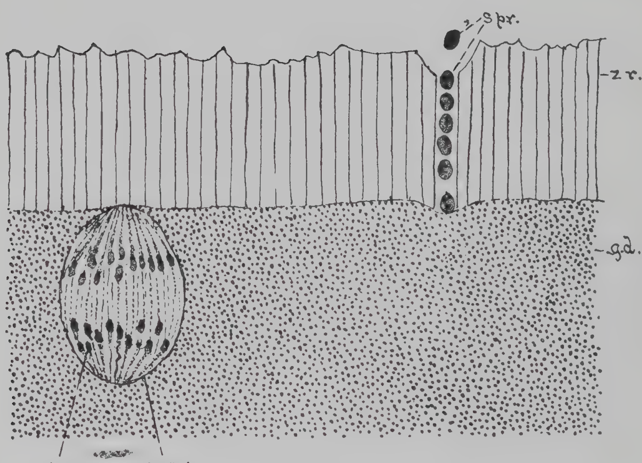

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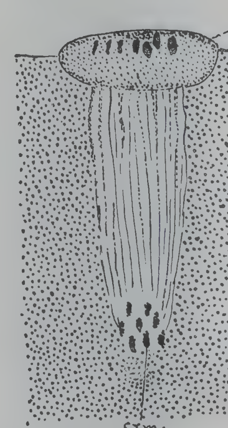

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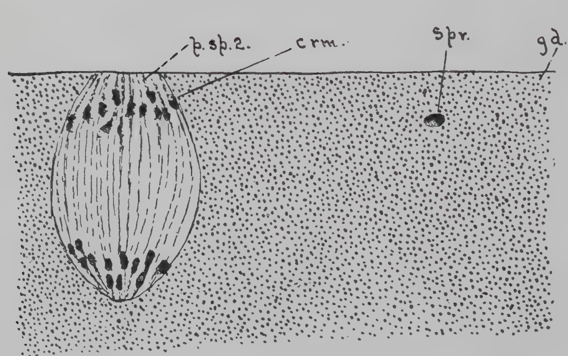

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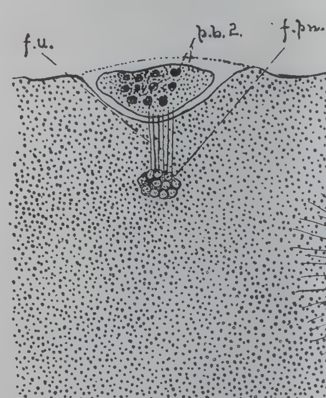

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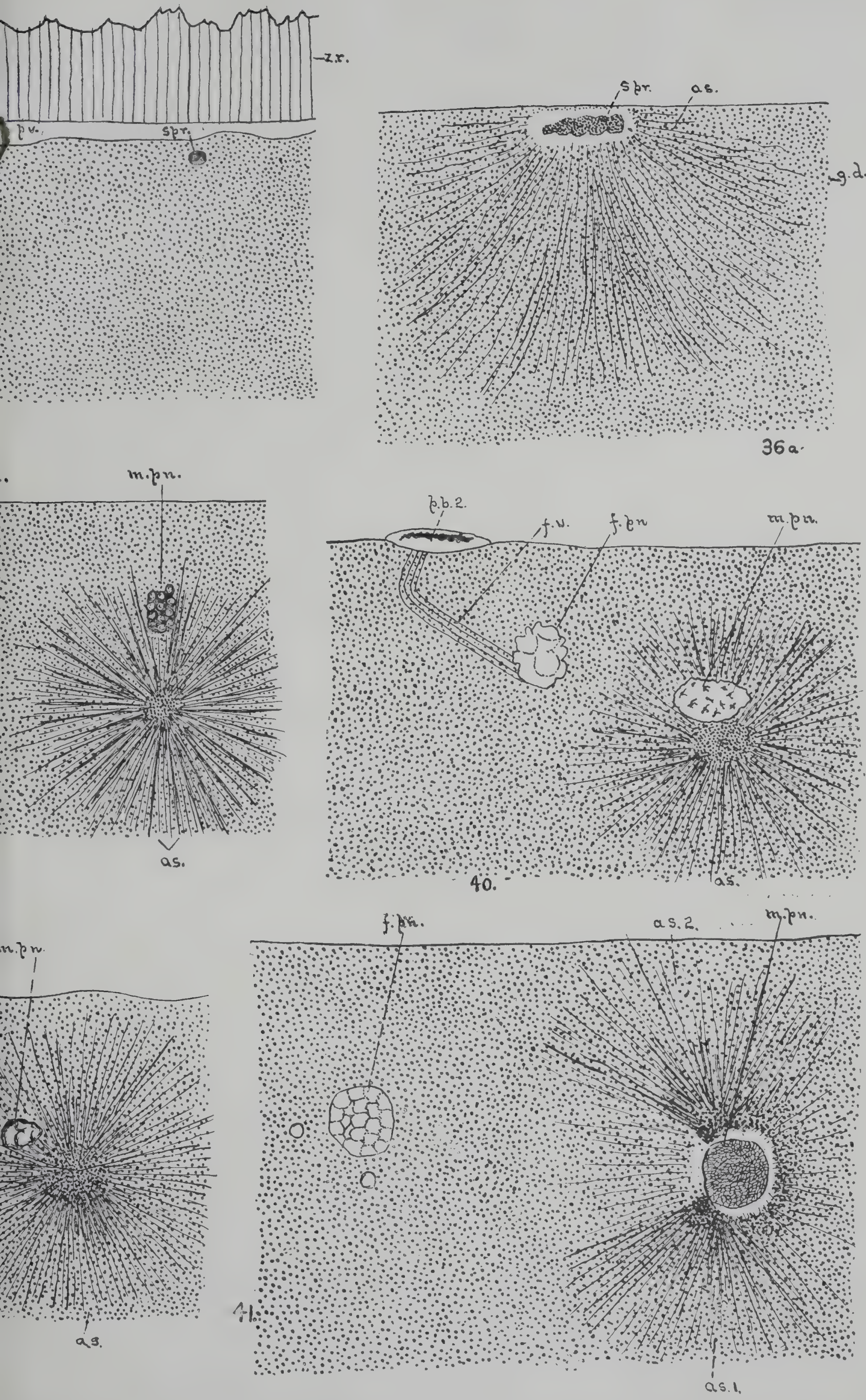
PLATE IV.



z.r.
p.v.
spr.
spr.
as.
g.d.
36a.
m.pn.
as.
p.b.2.
f.v.
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40.
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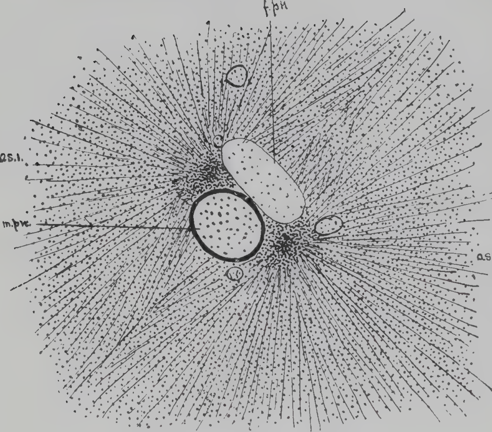
as.
41.
as.1.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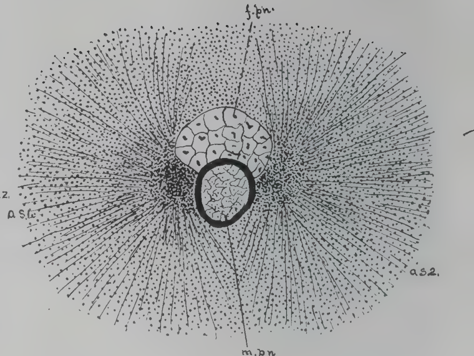
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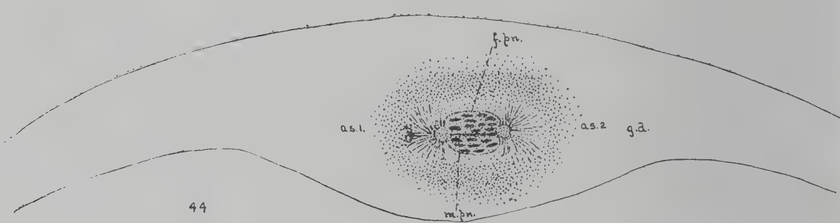
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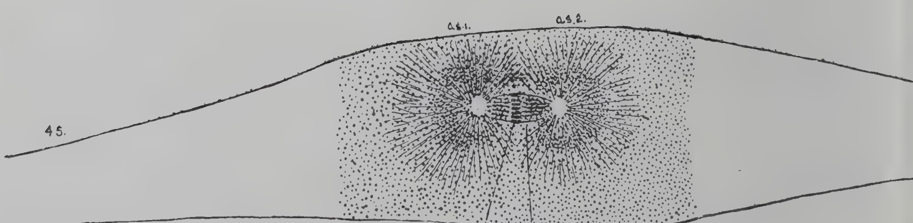
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as.2.
crm.
sy.sp.

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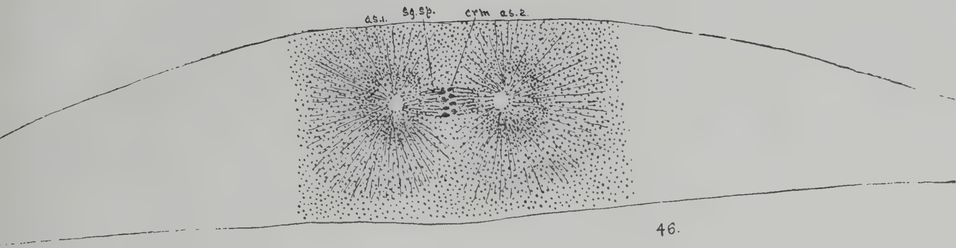
PLATE V.



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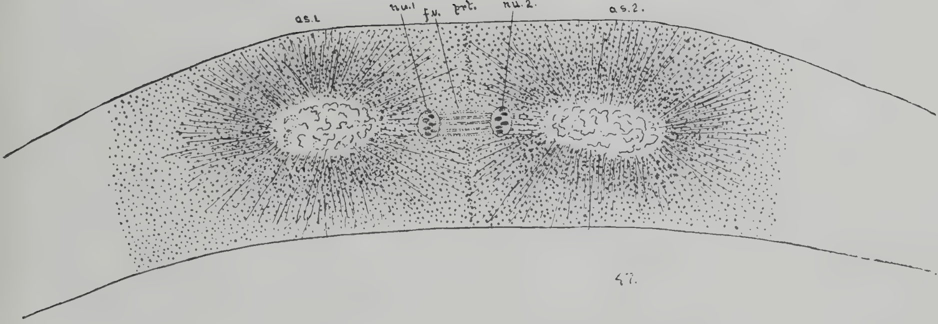

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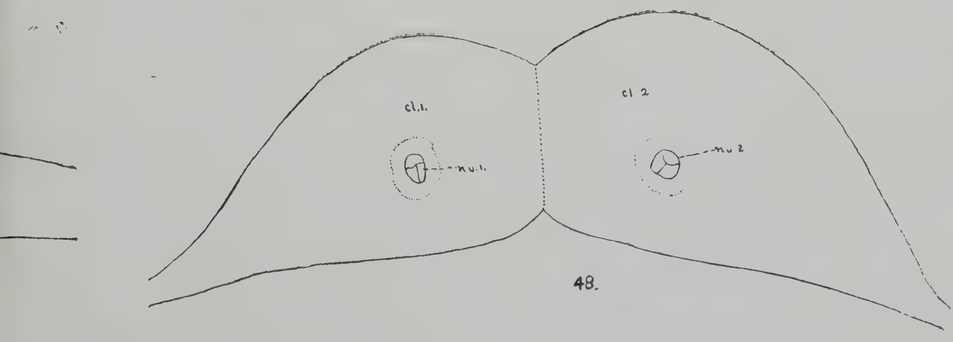

48.

INTRODUCTION.

The writer has been engaged at irregular intervals during the past two years in the study of the phenomena connected with the early development of the eggs of the wall-eyed pike. The observations on the egg cover the time between its extrusion from the body of the female and the appearance of the first segmentation furrow. They have been first made on the living egg and have been afterward verified and extended by the study of sections and other microscopic preparations of the eggs preserved by various methods. Owing to the peculiar interest which attaches to the wall-eyed pike, on account of the difficulty experienced by fish culturists in handling it, most of the observations refer to the egg of that species. In a few particulars the observations have been extended to the living eggs of other species, the whitefish, the perch, and the sucker. Taken together they afford a tolerably complete and, it is hoped, precise picture of what takes place in the egg during the time above indicated.

Most of the observations to be recorded have been made before on other species of fish, and some of them previously made on the wall-eyed pike have been already recorded in the publications of the State Fish Commission. In order to make the picture as complete as possible, and in order to give the preliminary knowledge necessary to an understanding of the facts now presented for the first time, the facts previously observed are here again presented. It will be noticed that these new facts form the larger part of the paper and it is believed that it is precisely these that are of the greatest interest to the practical fish culturist.

While this work was undertaken in the interests of practical fish culture, it has been carried out in the belief that these interests are in no way to be separated from those of pure science. From its birth modern fish culture has been associated with science. The history of fish culture contains the names of men eminent in science in all countries, and their published writings make up no inconsiderable part of the literature on fishes. These writings are scattered in the publications of many learned societies and other organizations and are in various tongues. A good work has been done by the United States Fish Commission in translating and publishing some of them, and in stimulating the production of others, but in spite of this work it remains true that a great part of this literature has never made itself felt among the men who are conducting the actual daily operations of fish culture.

Many of the facts recorded in this literature, and to be recorded, fix the conditions under which it is possible to conduct certain operations of fish culture, and yet these very facts are frequently wholly unknown to the men who are conducting these operations. Other facts which may seem to be at present wholly irrelevant are nevertheless necessary to an understanding of what is and what is doing in the operations of the fish culturist. He should study to understand the nature of his materials and of the processes that go on in these materials under the various conditions to which he subjects them. He will then be better able to meet new conditions, and when new difficulties arise, instead of submitting them to the whims of the fickle Goddess of Cut and Try, he will be able to attempt their solution by legitimate deduction from observed facts.

It is for the purpose of disseminating a knowledge of some of the facts of interest to the fish culturist, that the following account was written. It aims to make clear to the understanding, in so far as our present knowledge permits, precisely what takes place in the egg of a bony fish between the time when it is expelled from the body of the mother and the time when the first segmentation furrow appears. It aims to do this first, in the conviction that the understanding of the matter is in itself practical, and having done this, it points out the more obvious particulars in which the art may be advanced by this understanding of the science. The paper necessarily takes into account not only certain portions of the life of the egg, but also the corresponding periods in the life history of the spermatozoön, *i. e.*, its history from the time it is extruded from the body of the fish until the first segmentation furrow is formed on the egg. Whenever the observations of the writer have been incomplete they have been freely supplemented from the work of others and acknowledgment has been made of such indebtedness. On those points on which the observations herein recorded appear to be new or at variance with previous observations their exposition has been followed by a historical and a critical review of the literature bearing on the points in question.

In order to make some parts of the paper more intelligible to persons not familiar with the details of modern biology, it is preceded by an introductory section dealing with the cell structure of animals and more particularly with the details of structure in the individual cell and with the process of cell division.

PART I.

THE ANIMAL CELL AND CELL DIVISION.

It is well known that all animals are composed of minute units called cells. These cells are the elements of structure of which the animal is built up and bear the same relation to its body that the bricks or stones in a building bear to the building. The cells are usually microscopic in size and are by no means all alike. Just as the bricks or other materials used in the construction of a building must be adapted to the work that they have to, and must therefore differ from one another, so the cells composing the animal body are adapted to the work to be done, and differ from one another in accordance with the adaptation. Just as in the construction of a building we may have slates for the roof, bricks for the

walls and tiles for the floor, so in the construction of the animal body we have bone cells which have to do with the formation of the bony framework of the body, muscle cells which move that framework and nerve cells which initiate and control the movements of the muscle cells.

The materials used in the construction of a building may be totally different from one another, as clay in the brick of the foundations and wood in the walls of the superstructure. The substance composing the cells or units used in the construction of animal bodies is on the other hand nearly the same for all sorts of cells. This substance is called protoplasm. It is the protoplasm of a bone cell that forms about itself the hard lime-salt of which the bone is composed. It is the protoplasm of the muscle cell that contracts. It is the protoplasm of the nerve cell that starts or modifies the impulse that causes that contraction. Everywhere the material composing the cells of the animal body is protoplasm. That the protoplasm of a muscle cell must be different in some way from the protoplasm of a nerve cell is clear from the different work that it does and yet, just what the difference, is by no means clear.

The protoplasm composing an animal cell appears under the microscope as a semi-solid material, having very nearly the physical properties of the white of an egg. It thus changes form readily unless inclosed within a special envelope or cell wall. It is transparent. It is denser than water, so that when a mass of it is examined in water, it refracts the light more than the surrounding water and thus appears brighter. It commonly does not appear entirely uniform in structure but rather appears to be composed of a clear material in which are seen numerous very fine granules.

Protoplasm probably always occurs in the form of a cell and a cell is a very complicated mass of protoplasm. The shape of the cell depends on the work that it has to do, but we may take for purposes of illustration the spherical form, which is that common to most egg cells. If we examine such a spherical cell (Fig. 1) under the microscope we find it composed of a central denser portion, which is usually also spherical and which is called the *nucleus* (nu.). Its substance we may call *nucleoplasm*. We may suppose the diameter of the nucleus, as often happens, to be about one-third that of the cell. The protoplasm which surrounds the nucleus and makes up the body of the cell is called the *cytoplasm* (cyt.). Outside the cytoplasm is the cell wall or cell membrane (m. cl.) which incloses the cytoplasm as in a sac. The cell wall is not always present and is not regarded as an essential part of the cell. It may be looked upon as something outside the cell, formed by the cytoplasm as a protection to itself. As it occurs in probably all egg cells it is of importance in the present discussion, but it is not necessary to enter into an account of its structure. The structure of the cell protoplasm and of the nucleus is, however, a matter of the greatest importance for our purposes.

When a cell has been stained with solutions of such coloring matters as carmine or logwood, it is found that the nucleus does not stain uniformly. If such a nucleus be examined with a high power of the microscope, there are found running through it many threads which have become of a very deep purple or red color, according to the stain used. (Fig. 1 and Fig. 2, crm.) The threads are sharply marked off from the remainder of the of the nuclear matter by their deep color. Some of them are coarse and easily seen, while others are so fine that it requires great care to detect them. (Fig. 1.) They appear to be united with one another in such a way as to form a network, but it is possible that the threads do not actually

unite with one another, but that the finer ones cross one another or lie over one another in such a way as to give rise to the *appearance* of a network. The threads are called on account of the readiness with which they become colored *chromatin* threads, and the material of which they are largely composed is called *chromatin*. It must be remembered that a nucleus is a solid body, more or less spherical in form, and usually with a slight depression on one side. It may have thus the form of an apple, the depression in the side being represented by the depression in the apple at the bottom of which the stem is attached. When drawn on paper the nucleus is represented as a circle and the chromatin threads appear to occupy the whole area of the circle. (Fig. 1.) In reality the threads lie for the most part upon the surface of the nucleus and only a few of them extend into its interior.

That part of the substance of the nucleus which does not become stained is known as *achromatin*. It occupies the greater part of the center of the nucleus and lies everywhere between the chromatin threads both on the inside and at the surface. The achromatin itself is not structureless. It consists of fine colorless threads suspended in a colorless fluid, and in it are commonly to be seen one or more small spherical bodies which stain differently from the chromatin and are called nucleoli. In what follows I shall speak of the achromatin as though it were structureless, and I shall make no mention of the nucleoli, for the reason that our knowledge of both is very imperfect.

Covering the outer surface of the nucleus is a membrane, the *nuclear membrane*. (Fig. 1. m. nu.) It bears about the same relation to the nucleus that the skin of an apple bears to its contents. Its structure is not thoroughly understood.

One may represent the structure of the whole nucleus as here described by means of an apple. The white flesh of the apple may represent the achromatin and one may suppose that the core is absent and that the white flesh extends through the center of the apple. One may then think of the chromatin as represented by numerous branching threads lying beneath the skin of the apple and running for the most part over the surface, but sending processes here and there into the interior.

The nucleus lies within the cytoplasm so that it is surrounded by it on all sides. The cytoplasm (Fig. 1, cyt.), whether seen in a living cell or in a cell that has been stained and prepared for the microscope, appears composed of two substances, one liquid and the other more solid. The more solid portion of the cytoplasm appears to exist in the form of very fine threads, which appear to unite with one another so as to form a network. The threads, which will be spoken of as cytoplasm threads, run in all directions and unite with one another to form a network which is thus not unlike that formed by the strands of a fine sponge. One may form a very good notion of the structure of the cytoplasm by examining with a magnifying glass a small piece of ordinary bath sponge. In comparing the cytoplasm with a sponge it is necessary to think of the large passages in the sponge as filled with sponge material since these passages do not ordinarily exist in cytoplasm. It is necessary also to remember that the cytoplasm threads must be magnified probably a thousand times to appear as large as the sponge threads appear to the unaided eye. The liquid portion of cytoplasm is contained within the meshes formed by the cytoplasm threads very much as the water may be contained in the sponge meshes. It usually appears under the microscope as a homogenous, trans-

parent and colorless fluid or semi-fluid, but may contain small granules of various sorts. On account of its transparency it has been called *hyaloplasm*, but is also known under a variety of other names.

Surrounding the cytoplasm there is a membrane (Fig. 1, m. cl.) which incloses it as a sac. The membrane is not present in all cells and its character differs in cells of different sorts, so that its minute structure is not important in this connection.

In the cytoplasm there is a body probably of great importance in the economy of the cell, but the nature and behavior of which have been but recently made out. This is a very small spherical body which usually does not stain and which lies close against one side of the nucleus on the outside of the nuclear membrane. It is called the *centrosome* (Fig. 1, cn.). It frequently lies in a depression of the nucleus and if we compare the nucleus with an apple it may be thought of as lying in the depression of the apple which receives the stem. The cytoplasm threads appear to radiate from the centrosome. This is the case in cells that are about to divide, so that the appearance is then precisely as if each cytoplasm thread started from the centrosome and passed thence in a radial direction into the cytoplasm to be connected to neighboring threads by crossing strands.

Considering the cell as a whole we have then the following parts (Fig. 1). At or near the center is the *nucleus*, which has the form of an apple and is composed of two sorts of material, one more solid and readily stained is the *chromatin* and exists in the form of fine branching threads which run for the most part over the surface of the nucleus; the other more fluid is the *achromatin* which lies between the threads of chromatin and usually makes up the great bulk of the nucleus. The whole nucleus is inclosed within a *nuclear membrane*, which separates it from the cytoplasm.

Surrounding the nucleus is the cytoplasm, composed in its turn of a solid material in the form of a network of threads the *cytoplasm threads* and of a more fluid material the *hyaloplasm* which fills the spaces between these threads. The cytoplasm is thus like a sponge filled with water. In the cytoplasm and lying usually against a depression on one side of the nucleus is the *centrosome* from which the cytoplasm threads appear to radiate. The cytoplasm finally is inclosed within a membrane, the *cell menbrane.*

The whole structure may be represented diagrammatically as follows:

The cell composed of
- *Nucleus* composed of
  - achromatin.
  - chromatin threads.
  - nuclear membrane.
- *Cytoplasm* composed of
  - cytoplasm threads.
  - hyaloplasm.
  - centosome.
  - and sometimes inclosed in a cell membrane.

The entire cell is commonly of microscopic size; egg cells only are an exception to this rule among animals.

The nucleus is a governing center for many of the activities of the cell, controlling the cytoplasm in most of its functions. Thus the nucleus determines the form taken by the cytoplasm; it governs the movements of the cytoplasm; it governs the formation by the cytoplasm of the cell wall

and its character; it governs the digestive powers of the cytoplasm, for only under the influence of the nucleus is the cytoplasm capable of secreting digestive fluids. These relations between the nucleus and the cytoplasm have been determined by experiment, largely on unicellular animals. By cutting these animals in two in such a way that one part should contain the nucleus and the other be without a nucleus, and by then watching the behavior of that portion of cytoplasm that was without a nucleus, it has been possible to make out the relations existing between the nucleus and the cytoplasm.

It has been found that neither the nucleus nor the cytoplasm can exist alone. The cytoplasm nourishes the nucleus, furnishes it with food, so that any injury to the cytoplasm may result in the death of the nucleus through lack of nutrition. A portion of cytoplasm separated from its nucleus thus dies, and a nucleus separated from its cytoplasm dies also. It is only when the two are united to form a cell that continued existence is possible. In speaking thus of the function of the nucleus it is meant to include with the nucleus the centrosome, since it has not been found possible to separate it from the nucleus experimentally and since, in the forms usually experimented upon, the existence of the centrosome was not determined or taken into account.

Cells multiply by dividing, so that when a cell has grown to a certain size it divides into two, the cytoplasm falling into two parts, each containing half of the centrosome and half of the nucleus. It seems probable that that portion of the cell nucleus which governs the cell and determines its character is the chromatin. If this is true it follows that the chromatin is not alike in all cells, that in a muscle cell differing in some subtle way from that in a nerve cell. It is probable moreover that the threads of chromatin occurring in any one cell are not identical, but that possibly each differs in some particular from all the others and each has its peculiar part of the work to do.

Thus when a cell divides it becomes of importance that each of the two new cells thus formed should receive an exact half of each of the chromatin threads. At any rate we find in the division of a cell that a very complicated series of changes is gone through with and the purpose of these changes seems to be that each of the two daughter cells formed shall contain exactly one-half of each of the threads of chromatin contained in the mother cell.

The changes which occur in the nucleus of a cell when it is dividing have been included together under the term *karyokinesis.* A knowledge of this process is necessary to an understanding of the phenomena which take place in the egg of a bony fish during the period under discussion.

The first change that takes place in a cell about to divide is probably the division of the centrosome. At any rate in a cell preparing for division the centrosome is found to be double (Fig. 2.), although it is possible that the division into two may have taken place a good while before the time when the cell divides. The division of the centrosome is brought about by its lengthening into a rod-like body, by the subsequent constriction of this rod so that it becomes dumb-bell shaped, and by the final disappearance of that portion which corresponds to the handle of the dumb-bell. There are thus formed two centrosomes from the original single one. These centrosomes lie at first near one another and it is seen that the cytoplasm threads* now radiate from both centrosomes so that there are

* In speaking of the fibres or rays about the centrosomes as cytoplasm threads the writer does not mean to express any opinion as to whether they are or are not identical with the cytoplasm threads of the resting cell.

produced in the cytoplasm two star-like or sun-like figures (asters), each formed by radiating cytoplasm threads and each with a centrosome.

The cytoplasm threads radiating from each centrosome pass out in every direction, and if they were all cut off at the same distance from the centrosome their cut ends would thus form the surface of a sphere. Among the threads there are some which are thicker and and perhaps otherwise different from the remainder. These peculiar threads are grouped together in such a way as to form a *cone* (Fig. 2, con.). This cone is a part of the sphere formed about each centrosome by the cytoplasm threads. The apex of the cone is at the centrosome, and its base lies in the surface of the sphere and is directed toward the nucleus. There are thus two of these cones of cytoplasm threads, one belonging to each centrosome, and the axes of the two form with one another an angle, the apex of which is directed toward the nucleus.

At the same time that the centrosomes are dividing and the cones of cytoplasm threads are forming, the chromatin threads in the nucleus are undergoing changes. In the resting nucleus one does not readily recognize any regularity in the arrangement of these threads; one sees merely that they form an irregular network of coarser and finer threads lying near the surface of the nucleus (Fig. 1). As soon as the process of cell division sets in, the finer chromatin threads disappear. They seem to be drawn into the coarser threads. The result is that one sees only the coarser threads running in wavy lines over the nucleus. At the same time it becomes evident that these coarser threads have a regular arrangement, that they exist in a definite number (Fig. 2 and Fig. 8). The number is different in different cells, ranging from two to thirty-six or more. Each thread has the form of a loop, the closed end of which lies near the depression where the centrosomes are, while its two limbs pass thence in a wavy course near the surface of the nucleus, to end freely on the side opposite the centrosomes.

A single chromatin thread (Fig. 2, crm.) may be represented in this stage by drawing a line upon the surface of an apple. The line should start near a point on the side opposite the stem. It should pass thence in a wavy course to a point near the stem; there it should turn and pass again in a wavy course to end near its starting point. Eight or sixteen such loops drawn on the surface of an apple give a tolerably accurate notion of the arrangement of the chromatin loop in this stage, with this exception, that there are usually one or two chromatin loops that do not lie on the surface of the nucleus but in the center. The heads or closed end of the deeper loops are, however, directed toward the centrosome, while their free ends lie on the side of the nucleus opposite the centrosome.

The arrangement of the chromatin threads that is now evident probably exists in the resting nucleus, but is there obscured by the numerous finer threads which pass out from the coarser ones. Upon the withdrawal of the finer threads into the coarser ones the arrangement becomes at once evident. If one examines the figure of the resting nucleus (Fig. 1.), it is not difficult to trace some of the coarser chromatin threads in the form of loops and one can readily see that if these threads were still further thickened by the withdrawal into them of the finer threads there would result the arrangement shown in Fig. 2. It is probable also that a definite number of chromatin threads exists in the resting nucleus, but that this fact is obscured by the finer threads and only becomes apparent upon their withdrawal.

Another fact which comes out clearly in this stage, is that each chromatin thread is made up of a large number of chromatin particles which are attached to one another to make the chromatin thread. These particles have usually the form of discs, and are held together by their flat sides by a colorless material, so that their relation to one another is like that of the coins in a pile or the beads in a string. These ultimate particles of chromatin are called *microsomes* (Fig. 2.), while the loops which they compose are called *chromosomes.*

In the next stage* the two centrosomes separate from another and travel toward opposite sides of the nucleus, so that one of them (Fig. 3, b.) becomes to lie on one side of the nucleus, while the other (Fig, 3, a.) lies on the opposite side of the nucleus. After this change of position is effected a line connecting the two centrosomes forms nearly a right angle with a line drawn between them before the change in position is effected. (Compare Figs. 2 and 3.) The two cones of cytoplasm threads have become meantime larger and the individual threads more prominent. Owing to the change in position of the centrosomes the axes of the two cones no longer form an angle with one another but lie nearly in a straight line. The result is that the bases of the two cones are brought nearly together and the two cones form the two halves of a spindle (Fig. 3, sp.) which becomes more perfect in the succeeding stages.

While the centrosomes are separating from one another and the cones of cytoplasm threads are shifting position, changes are taking place in the chromatin loops. They become much shorter and thicker (Fig. 3.) and at the same time lose their wavy outline. Each loop becomes thus U shaped. At the same time each becomes split lengthwise into two loops which lie side by side (Fig. 3, [1] and [2].) If the loops first present are spoken of as mother loops the two loops into which each splits may be called daughter loops. The two daughter loops derived from each mother loop lie close against one another and parallel to one another so that it requires a careful examination to see that the splitting has taken place. Each daughter loop is made up of a row of *microsomes* (not represented in the figures) as was the mother loop from which it came and it seems likely that in the splitting each microsome of the mother loop has been divided into two, one for each daughter loop.

Another change noticed in this stage is the disappearance of the nuclear membrane. Its position is represented in the figure by a dotted line. It becomes gradually less distinct and finally disappears, but it is not certainly known what becomes of it. The nuclear material is thus brought into direct contact with the cytoplasm so that it is possible for a mixture of the two to take place, although it is not known that such mixture does actually take place.

At about the time that the nuclear membrane disappears the threads composing the two cones are seen to be attached to the chromatin loops. (Fig. 3.) From each daughter loop a considerable number of these threads, as many as sixteen or twenty, passes to one of the centrosomes. From the other daughter loop of the same pair threads pass to the opposite centrosome. Thus of the two loops composing each pair one is attached by the cytoplasm threads of one cone to one of the centrosomes and the other by the cytoplasm threads of the other cone to the opposite centrosome.

* In this and some of the following figures the microsomes are not represented and only two chromosomes are represented. This is in order to make the figures less complicated.

In the next stage (Fig. 4.) there occurs a contraction and consequent shortening of the fibres composing the two cones. The result of this shortening must be to pull upon the loops and since one of the daughter loops composing each pair is attached to one centrosome while the other loop of the same pair is attached to the opposite centrosome, the tendency is to pull apart the daughter loops composing each mother loop and to bring one of them toward centrosome *a*. and the other toward centrosome *b*. The chromatin would thus be divided into two equal portions.

But for some reason not well understood the daughter loops do not at first separate from one another. They are still held together in pairs, probably by some part of the achromatin of the nucleus. It is only in a later stage that this material uniting the daughter loops gives away, so that the force exerted by the contraction of the threads of the two cones is able to separate the daughter loops from one another. Since the contraction of these cone fibers is not at first able to pull apart the pairs of daughter loops, one of three things must happen. If the pull exerted by the shortening of the fibers passing to one centrosome, the centrosome *a*, for instance, (Fig. 3) is stronger than that exerted by the fibers passing to the opposite centrosome, *b*, the pairs of loops will be all drawn toward centrosome *a*. If the pull exerted by the fibers attached to centrosome *b* is stronger the loops will all be drawn toward *b*. On the other hand if the pull exerted from *b* is exactly equal to that exerted from *a* the loops will all be brought to a position half way between *a* and *b* and into a plane at right angles to the line connecting *a* and *b*. This is what happens. The heads or closed end of the loops are at the same time brought close together while the free ends extend in the one plane in all directions from the point about which the heads are grouped (Fig. 4).

The result of this contraction is, further, that the bases of the two cones of fibers become plane and are brought accurately together, and since the cones are exactly alike, they form together a spindle, the *achromatic spindle* (Fig. 4, sp.). The plane which is formed by the contact of the bases of the two cones is called the equatorial plane and in it lie the chromatin loops, while the spindle fibers extend in opposite directions to meet on each side in the centrosomes and thus form the spindle. In addition to those spindle threads that run from the chromatin loops to the centrosomes and form the greater part of the spindle, there are some spindle threads, as shown in Figs. 4 and 5, that run directly from one centrosome to the other along the middle of the spindle and form thus what is known as the central spindle (Hermann). The division of each chromatin loop into the two daughter loops is still evident (Fig. 4). An examination of each pair of daughter loops shows that one of its two constituents is attached exclusively to one of the centrosomes and that the opposite constituent is attached exclusively to the opposite centrosome. All the daughter loops attached to centrosome *a* lie consequently on that side of the equatorial plane which is turned toward centrosome *a*, while all the daughter loops attached to centsosome *b* lie on that side of the equatorial plane turned toward centrosome *b*. Consequently a section made through the equatorial plane would divide each chromatin loop into two equal daughter loops and the whole mass of chromatin into exactly equal halves.

In the stage which is now reached the chromatin loops have their heads together and their free ends radiate in the equatorial plane in all directions from the center of the spindle. When the chromatin loops are looked at

from the end of the spindle, *i. e.*, along the line joining the two centrosomes, the figure formed by them is that of a star (Fig. 4a), in the middle of which one of the poles of the spindle may be seen. From this arrangement of the chromatin loops the stage is called the *mother star* stage, while the preceding stages, during which the arrangement of the chromatin loops has been less regular, is known as the *mother skein* stage.

As soon as the chromatin loops are brought into the form of a mother star, the bond or force, whatever its nature, which has previously united the daughter loops into pairs, is overcome by the pull of the spindle fibres. The result is that the two daughter loops are pulled apart. One is drawn toward one centrosome (as a) and the other toward the opposite centrosome (as b). Since the strongest pull is exerted where the spindle fibres from a act in direct opposition to those from b, and since this is at the heads of the chromatin loops, the separation of the daughter loops occurs first at their heads (Fig. 5.). The head of one daughter loop of each pair is thus seen to be drawn toward a, while the head of the opposite loop is drawn toward b, and at the same time the free ends of the loops remain united to one another in the original pairs.

As the spindle fibres continue to shorten the heads of the loops are drawn further and further apart until the loops (Fig. 5, 1 and 1^1 and 2 and 2^1) are united to one another only by their free ends.

From the time when the heads of the loops begin to separate until the loops are entirely separated the stage is called that of *metakinesis* (Fig. 5).

The continued action of the spindle fibres finally pulls apart the free ends of the daughter loops, so that each loop is separated into its two constituent daughter loops.

When this is accomplished the stage of *metakinesis* is at an end.

When the daughter loops are separated from one another (Fig. 6.) they are brought toward the centrosomes by the continued action of the spindle fibres, so that very soon half of the entire number of daughter loops is grouped about one centrosome while the other half is grouped about the opposite centrosome. The heads of the loops lie next the centrosome while their free ends pass out from it and extend toward the equatorial plane.

When one looks at the mass of chromatin loops along the axis of the spindle (the line connecting the centrosomes) the loops still form the figure of a star, at the center of which is seen a centrosome with spindle fibres about it. In this case the rays of the star are daughter loops and not, as in the preceding stage, mother loops. This stage is called consequently the *daughter star stage* (Fig. 6). It lasts from the time the daughter loops separate from one another until they have taken up their position about the centrosomes.

As soon as the daughter loops have taken up this position they begin to elongate and at the same time each becomes sinuous in outline (Fig. 7.) and sends out numerous finer chromatin threads (Fig. 8. lower cell). In other words a process is gone through which is the reverse of that gone through by the mother nucleus in passing from the resting stage to the mother skein stage. This process leads first to a *daughter skein* stage and then to a *daughter resting nucleus*.

While the loops are thus sending out the secondary finer chromatin threads, they become continually longer and more sinuous in outline (Fig. 8) and become so curved that they form the surface of a sphere. On one side of this sphere lies the centrosome (cn.), and as long as the

loops are visible as such it may be seen that they are grouped with their heads about the centrosome, and their free ends upon the side of the sphere opposite the centrosome. Their arrangement with reference to the centrosome is thus precisely the same as the arrangement of the mother loops with reference to the centrosome in the original nucleus, (compare Figs. 1 and 2, and Fig. 8). At the same time the nucleur membrane (Fig. 8. m. nu.) reappears, but it is first seen on the side of the nucleus opposite the centrosome and gradually extends until it surrounds the whole nucleus. The smaller chromatin threads now become more numerous and their branching more pronounced until finally the loops are no longer distinguishable and the chromatin of the nucleus appears to form only an irregular network. When this has taken place the cell contains two daughter nuclei, each containing one-half of each of the chromatin loops of the mother nuclues and each precisely like the resting mother nucleus but smaller.

While these daughter nuclei are going through the final changes which bring them into the resting condition, the cytoplasm divides into two portions. This takes place by the formation of a constriction about the cell body in the equatorial plane (Fig. 7). The constriction makes the cell dumb-bell shaped and each of the ends of the dumb-bell contains one of the daughter nuclei. Finally that portion of the cell which corresponds to the handle of the dumb-bell divides and there are two cells. The final division of the handle of the dumb-bell or connecting strand may take place by a deepening of the original constriction, or it may be due to the formation of a transverse double partition wall (Figs. 7 and 8, *prt.*), which is continuous with the cell wall on either side of it. The two layers of this partition wall then separate and each forms a part of the cell wall of the cell of its side.

The result of the whole process of nuclear division and of cell division is that each of the daughter cells is precisely like the mother cell from which it came. Each contains not only the same materials but also an exact half of each. Each daughter cell contains its part of the original centrosome, of the cytoplasm and its exact half of the chromatin. The meaning of this will become clearer as we proceed.

PART II.

THE EGG CELL.

A.—THE FRESHLY EXTRUDED EGG OF THE WALL-EYED PIKE.

When pressed from the body of the fish by the usual process of stripping, the eggs of the wall-eyed pike come away along with a small quantity of a colorless somewhat viscid fluid. If a mass of the eggs is allowed to stand in a cylindrical vessel this fluid appears in small quantity at the top and it may then be drawn off from the eggs with a pipette or decanted. The corresponding fluid of the Rhine salmon has been studied by Miescher and found to be albuminous. Hensen ('83) has found that in the cod it makes up 20% of the spawn, contains albumin and is strongly alkaline.

In the wall-eyed pike the fluid is no more adhesive than a very dilute egg-albumin. Thus if one places a drop of this fluid between two pieces of glass, wood or cloth and presses the pieces together, they do not become glued to one another. If the pieces are then placed in water they do not

adhere to one another. This shows that the fluid bathing the eggs does not set or become adhesive by the action of water. It is strongly alkaline and mixes readily with water without giving any precipitate. The quantity of the fluid is variable. When the eggs pass from the fish under very gentle pressure, it is considerable but has not been quantitatively determined. Such eggs are readily fertilized and are considered to be fully ripe. When the eggs are obtained from the fish only by the use of considerable pressure, the amount of fluid is less and such eggs commonly show a smaller percentage of fertilization and are regarded as not fully ripe.

Ryder ('82) has suggested that this fluid, which occurs generally in Teleosts, serves in the cod as a lubricant during the passage of the eggs from the body. This is doubtless true. That it serves also another purpose will appear under the head of fertilization. Ryder adds:—"In other cases it serves to glue the eggs together in masses or bands or to cause them to adhere firmly to fixed objects in the water." The substance which causes the adhesion of the egg of the wall-eyed pike, to be mentioned presently, is not the fluid now under discussion. It has been shown that this fluid possesses no peculiar adhesive properties, either by itself or under the action of water. The true adhesive substance of the egg of the wall-eyed pike lies beneath the fluid which bathes the eggs and forms the outer egg membrane.

The eggs of the wall-eyed pike are yellowish or reddish in color. The color varies from fish to fish, but all the eggs of the same fish are of the same color and the color is located principally in the oil drop.

The eggs vary considerably in size in different individuals, but those of the same fish are nearly of a size. This is more noticeable after the eggs have become distended by lying for some time in water. The limits of the variation in size have not been determined, but the average size is one-nineteenth of an inch.

The eggs are soft to the touch like little balls of putty. They are nearly spherical in form, but are indented and flattened by mutual pressure so as to be somewhat polyhedral, like so many putty balls closely packed together.

When the egg is examined under a low power of the microscope in the fluid which covers it naturally, a number of parts may readily be distinguished in it (Figs. 9 and 10). These will first be enumerated and then described in more detail.

Making up the greater part of the bulk of the egg in its present condition and lying at its center is the yolk (yk.). It is spherical and transparent. On the upper side of the yolk (the side turned toward the observer) is a deep excavation which has the form of somewhat more than half a sphere and lodges a spherical, homogeneous oil drop (o. d.). The outer surface of the oil drop projects somewhat from the excavation beyond the level of the surface of the yolk, forming thus a sort of low, rounded elevation or boss. Close against the surface of the yolk is a layer of protoplasm which appears granular under the microscope in the living egg (Fig. 9, cr.). It may be called the cortical layer of the egg. It invests the exposed portion of the surface of the oil drop as well as the yolk, and on one side of the yolk it is slightly and irregularly thickened. The thickened portion (g. d.) is known as the germinal disc and becomes much more pronounced in later stages. Still outside the cortical layer and close against it is the egg shell (z. r.), in which may be seen fine radiating lines running from its inner surface to near its outer surface.

We may now examine each part of the egg in more detail.

1. The *cortical layer* is the protoplasm or living portion of the egg and corresponds to the cell protoplasm of other cells. It alone is seen in later stages to be capable of movement and from it alone the young fish is formed. The other portions of the egg serve the cortical layer, the yolk as food material, the egg shell for protection. In the fresh, living egg the cortical layer has the appearance of a clear material like the white of an egg in which are imbedded numerous fine granules, which are denser than the medium in which they lie and appear consequently either darker or lighter according as one changes the focus of the instrument. Besides these apparent granules the cortical layer contains a large number of spherical bodies (Figs. 9 and 10, c. dr.). These bodies appear either dark or light according to the focus, and are slightly pink in color. Since they are less dense than the surrounding protoplasm I have called them cortical drops. They are entirly homogeneous and free from granules and are so closely set over the surface of the yolk that they commonly appear to be in contact with one another (Fig. 10) and the surface of the yolk is exposed only here and there in the intervals between them. The cortical drops vary in diameter from .012 to .040 mm., but by far the larger number measure between .025 and .036 mm.

The structure of the cortical layer may be made out in more detail in eggs that have been preserved either in Hoffmann's fluid or Perenyi's fluid. If eggs are stripped from the female into either of these fluids, without coming into contact with water, and are afterward preserved in alcohol, it is found that the whole cortical layer may be readily removed from the yolk. After pulling away the egg shell with needles one may remove the cortical layer over about one-third the surface of the yolk, preferably in the region of the oil drop, and by manipulating with needles one may then succeed in shelling the yolk out of the cortical layer. The cortical layer may then be prepared for study with high powers of the microscope.

When it is examined with an ordinary lens it appears as a thin walled sphere. Its walls are of nearly uniform thickness, but on one side there is seen an irregular accumulation of its substance to form the germinal disc. The germinal disc may be triangular, square or nearly circular, and has a diameter equal sometimes to only about one-eighth the circumference of the sphere of cortical substance, but extending sometimes in certain directions over one-half of its circumference. The disc is thickest in the middle, but towards its edges becomes gradually thinner and so passes insensibly into the remaining portion of the cortical layer. From its borders there pass out strands or streamers which extend into the cortical sphere as the meridian circles on a globe extend from the pole. These streamers are due to thickenings of the cortical layer, radiating extensions of the germinal disc. They become gradually thinner and less distinct as they extend toward the equator of the sphere and disappear entirely just before reaching it. Sometimes the germinal disc is represented by two thickened patches of the cortical protoplasm, and in such cases the two are united by a thickened strand of cortex and from each of them pass out radiating bands.

If a thin piece of the cortical layer be stained and examined under a high power of the microscope, it is easy to make out its structure. It consists of two substances, a denser material in the form of fine threads, cytoplasm threads, which unite to form a sponge work, and a less dense material which fills the meshes of the sponge-work. The sponge-work

formed by the network of cytoplasm threads is probably nowhere seen with greater clearness than in the cortical layer of the eggs of bony fishes. In the same preparation may be seen the cortical drops (Fig. 22, c. dr.). They appear spherical, but most of them have shrunken slightly under the action of the reagents used, so that they no longer quite fill the spherical cavities in which they are lodged. The reagent used has caused a change in the physical properties of the drops. They no longer appear fluid but are solid. They are no longer transparent and homogeneous but each is made up of a large number of very minute spherules (Fig. 22) and is consequently opaque.

The chemical nature of these drops is a matter of interest, and in order to determine it approximately pieces of the cortex were subjected to the Berlin blue test as follows:—They were first laid in a solution made by dissolving one gram of potassium ferro cyanide in 20 cc. of water, and adding to this 10 cc. of glacial acetic acid. After remaining an hour in this solution the pieces are washed in repeated changes of 60% alcohol. The alcohol which is removed from the pieces after the third washing is tested by dropping into it a few drops of a 1% solution of ferric chloride. If any of the potassium ferro cyanide remains in the alcohol there will result a precipitate of Berlin blue. If a blue color is found, the washing of the pieces is continued and the alcohol used in washing is tested until it no longer gives a precipitate with the ferric chloride. The pieces of cortical layer are then transferred from the alcohol to a 1% solution of ferric chloride. It is a peculiarity of albumen, after it has been acted on by certain acids, as chromic acid, that after being soaked in potassium ferro cyanide it retains some of the ferro cyanide even although thoroughly washed with alcohol. Other substances give up the ferro cyanide to the alcohol used in washing them. The result is that when any piece of tissue treated as above, and containing an albumen along with other chemical bodies, is transferred to ferric chloride, there is produced in the albumen an intense blue color, due to the formation of Berlin blue, while the other substances in the tissue remain uncolored. It is thus possible by this test to distinguish albumen from other constituents of the tissue examined.

When the pieces of cortical layer are transferred to the ferric chloride it is found that the cortical drops become of a bright blue color and are thus shown to be albuminous. Tests which attempt to determine the precise chemical nature of small quantities of organic substances examined under the microscope are not always reliable and this is particularly true of the albumens. The fact that the cortical drops yield the blue color to the above test is thus not final evidence of their albuminous nature, but is sufficient for the present purpose. The only really satisfactory method of determining finally the chemical nature of the cortical drops is to collect them in sufficient quantity to be able to subject them to an accurate quantitative analysis. As it seems possible to do this I have not attempted to decide the question by less perfect methods and have not had the opportunity to decide it by chemical analysis.

If one examines more carefully a preparation made as above by the Berlin blue test, one finds that the blue color is not confined to the cortical drops, but that it appears in the cytoplasm outside the drops and in that portion of the cytoplasm which lies between the cytoplasm threads, *i. e.*, in the hyaloplasm. The effect of the reagents used in preserving the eggs is to cause a precipitate of fine granules or spherules in the hyal-

oplasm. These granules resemble closely those that appear under the same treatment in the cortical drops and occupy the spaces in the meshwork of cytoplasm threads. The granules are so small that the blue color of a single one of them is hardly to be made out at all by the use of the microscope. It is only when a considerable thickness of the cortical layer is examined so that the blue granules are present in large numbers and lie above one another in several layers that one sees the distinct blue color in the cytoplasm. It is impossible under such circumstances to make out with certainty whether the blue color is in the cytoplasm threads or in the granules which occupy the spaces between these threads. The statement that it is the hyaloplasm or material in the meshes of cytoplasm threads which is thus stained blue and is consequently albuminous is founded on the behavior of the hyaloplasm when treated with a solution of orange (one of the aniline dyes). The matter will be taken up again presently.

The cortical drops occupy the whole thickness of the thinner portions of the cortical layer, but in the thicker portions, *i. e.*, in the region of the germinal disc, most of them lie near its outer surface and consequently close against the zona radiata (Fig. 9).

We may add somewhat to our knowledge of the cortical layer by an examination of thin sections. These sections should not be thicker than one five-thousandth of an inch. Some of those used were made from pieces of the cortex that had been subjected to the Berlin blue reaction, while others were stained, first in a solution of gentian violet and afterwards in a solution of orange.

In sections made from pieces of cortex subjected to the Berlin blue process there is little additional to learn with regard to the drops themselves (Fig. 18). The blue color is seen, and the fact that drops are made up of little granules is perhaps more evident than before. The position of the drops comes out very clearly, and it is seen that in the regions where the cortex is thin each drop occupies its whole thickness. At first sight it appears that the drops are not covered by cortex on their inner surface, but lie directly against the yolk; but an examination of sections shows, on the contrary, that the cortical drops are covered on their inner surfaces by the cortical layer and are thus entirely separated by it from the underlying yolk (Figs. 9 and 18).

Another point that strikes one in these sections is that the layer of cytoplasm that covers the outer surface of the cortical drops and separates them from the egg shell is extremely thin (Fig. 22). It is hardly possible to imagine a layer of protoplasm thinner than this one. The cortical drops are thus almost in contact with the egg membrane, and the slightest force would seem to be sufficient to rupture this thin layer of protoplasm and allow them to come into contact with the egg shell. This thin layer of cytoplasm appears, when examined in surface view, to consist of cytoplasm threads arranged almost in a single plane like the meshes of a net.

If one examines sections that have been stained with gentian violet and orange, it is found that the cytoplasm threads have taken on the blue color of the gentian, while the hyaloplasm occupying the spaces between the cytoplasm threads, has taken the orange stain. The two substances are thus sharply differentiated from one another. Very much the same effect may be produced by using picric acid in place of orange. It is now worthy of note that the cortical drops are also colored yellow by the orange stain. Thus the statement that the material composing the cor-

tical drops is nearly or quite the same as that composing the hyaloplasm receives an additional support.

We are thus perhaps justified in thinking of the cortical drops as merely accumulations of hyaloplasm, as spherical cavities in the cortex filled by the flowing into them of the more fluid hyaloplasm which lies between the cytoplasm threads. If we compare the whole cytoplasm to a sponge filled with water we may think of these cortical drops as corresponding to the large holes or passages in the sponge also filled with water. One cannot deny the fact that there may be in the cortical drops chemical substances different from those found in the hyaloplasm or vice versa, but all that is here insisted on is a very probable identity.

If we then sum up the knowledge that we have gained of the cortex of the egg of the wall-eyed pike, we may say that it exists in the form of a thin layer covering the yolk and oil drops; that it is irregularly thickened on one side to form the germinal disc, and that from the disc streamer like thickenings extend toward the equator of the egg; that the structure of the cortex is like that of other cell protoplasm in that it consists of a sponge-work of cytoplasm threads inclosing an albuminous fluid, the hyaloplasm; that it contains also numerous spherical cavities filled with an albuminous material, probably identical with the hyaloplasm, and that this material exists thus in the form of drops, the cortical drops; that the cortical drops are entirely surrounded by cytoplasm, but are separated from the egg shell by an extremely thin layer of it.

2. *The nucleus.* Most observers have failed to find the nucleus in the freshly laid egg of bony fishes. Hoffmann ('82) has described it in several forms in the living egg, but so much doubt has been thrown on the accuracy of Hoffmann's observations of other phenomena described in the same paper that one hesitates to accept his statements on the point in question. Agassiz and Whitman have described the nucleus in fertilized eggs five minutes after fertilization. The writer has not undertaken to find it in unfertilized eggs and in fertilized eggs has seen it only after the lapse of twenty minutes. It is only to be seen in sections, and is at the time mentioned in one of the phases karyokinesis. There is a well marked achromatic spindle (Fig. 9, nu. and Fig. 34) which is nearly at right angles to the outer surface of the egg and is situated near the middle of the germinal disc. One of its poles is just beneath the surface of the disc. Centrosomes are not visible and the spindle lies in the cytoplasm like a foreign body, without producing any effect on it. The ends of the spindle where the centrosomes should be are not surrounded by suns or spheres of radiating cytoplasm threads, such as are usually present. About the equator of the spindle, as described by Boehm, are about a dozen chromosomes, and each is rod-like and distinct (Fig. 34). As the history of the nucelus in the fertilized and unfertilized eggs is identical during the first hour or so after they have come into contact with water there can be no difference between the nuclei of fertilized and unfertilized eggs at the end of five or twenty minutes, and the nucleus of the unfertilized egg is no doubt at that time in the stage of the mother star. In other words the egg, when it leaves the body of the parent fish, has already gone part way through the process of cell division. It passes through the remainder of the process at a somewhat later stage in its history, but the earlier part of the process must be gone through with before the egg is laid, while it is still in the ovary. The writer has not examined the eggs of the wall-eyed pike while they are still within the ovary, but such eggs have been described by many

writers, and by all of them the nucleus has been described as not undergoing division but as apparently in the resting stage. When the egg is laid the process of karyokinesis is found to be already well advanced, so that the earlier stages of this process must be gone through with just before the egg leaves the ovary. These earlier changes in the nucleus of the Teleost egg, whatever their nature, have not yet been investigated.

3. *The yolk* (yk. in all figures) of the egg of the wall-eyed pike is spherical, and marked on one side by a somewhat more than hemispherical depression in which lies the oil drop. In the freshly laid egg which has not come in contact with water, the yolk is so concealed by the cortical drops that one catches a glimpse of it only here and there between the drops. When the egg has lain a moment in water and the cortical drops have disappeared, the yolk is seen to be transparent, homogeneous and colorless. It looks like a little sphere of pure glass. It is of a fluid or semi-fluid consistence and is readily pressed out of shape by the weight of the egg or by the pressure of adjacent eggs. Under the action of picro-acetic acid or Perenyi's fluid, the yolk becomes cartilage-like in texture, while under the action of most mixtures containing chromic acid it becomes very hard and brittle. When such yolks are examined either by teasing them into pieces with needles or by sectioning them, they are often found to be traversed by small canals which radiate from the center toward the surface and many of which end in the depression which contains the oil-drop. These canals often give to the yolk a radially striated appearance. I have never seen them in the fresh yolk and am inclined to think that they are due to the action of the reagent. Similar canals have been described by Reichert ('56) in the pike.

When the cortex and egg membrane are ruptured, so that the yolk may come into contact with water, it immediately breaks up into a multitude of minute spheres. These spheres are very small even under the high power of the microscope, and they adhere together into a viscid, stringy mass which is difficult to remove when it is once smeared over any object. The yolk thus changed appears opaque and milk white instead of transparent as formerly. A very small quantity of yolk added to water suffices to make it milky, but the milkiness disappears upon adding to the water a small quantity of salt, thus showing the solubility of the yolk in salt solution. The peculiar behavior of the yolk toward water is common to the eggs of many Teleosts. The moment the egg is so injured that water gets access to the yolk, the latter turns white, so that one of the surest signs of an injured or dead egg is its whiteness.

The *oil drop* is inclosed in the excavation on the side of the yolk. It is homogeneous and transparent and of a yellowish, golden or reddish salmon color. Its solubility in ether, its blackening in osmic acid, and its floating on water indicate that it is oil. The oil drop is the lightest part of the egg, so that when the egg is placed in water and is free to move, the side upon which the oil drop is situated is always turned uppermost. There are commonly a few very small oil drops situated around the larger one in the substance of the yolk near its surface. Their number is variable and they are too small to be of practical consequence.

The yolk has been spoken of as though it were entirely separate from the cortex and merely in contact with it by its outer surface. This appears to be the case when one sees how readily the cortical layer may be removed from the yolk in eggs preserved by certain methods. An examination of sections shows, however, that the plane that separates the yolk from the

cortical layer is not a definite one; the cortical layer rather merges gradually into the yolk, so that there is no plane upon one side of which it can be said there is yolk only while on the opposite side there is cortex only. If one examines a thin section passing through the germinal disc and the underlying yolk, it is seen that the meshwork of cytoplasm threads is coarser on the lower surface of the cortex and that the hyaloplasm is consequently more abundant. Beneath the middle of the germinal disc this network is coarsest, the meshes here being four or five times as large as elsewhere. This meshwork of cytoplasm threads can be fcllowed for a considerable distance into the yolk underneath the germinal disc. It becomes coarser and is lost sight of as one passes toward the center of the yolk. What is thus true of the relation of the yolk to the cortex under the germinal disc is true in a lesser degree of its relation to the cortex elsewhere. It is possible that the network of cytoplasm threads extends quite through the yolk and connects the cortex of one side with that on the opposite side, but this has by no means been proved. We may thus think of the superficial layer of the yolk (and possibly of the whole yolk) as resembling the cortex. We may think of it as cytoplasm with its threads greatly reduced in volume and their enlarged meshes occupied not by the usual hyaloplasm, but by yolk material. Whereas in the cortex the cytoplasm threads are equal to the hyaloplasm in volume, in the yolk the cytoplasm threads are far surpassed in volume by their contained yolk.

The *perivitelline space* (sub-zonal space, intercapsular space, breathing chamber): In describing the cortical layer it has been spoken of as though it were directiy in contact with the egg shell and so it appears to be in a freshly laid egg that has not come into contact with water. But if one examines such an egg with care there is always to be seen a very thin, colorless line, which indicates the existence of a slight space separating the cortex from the egg shell at every point. This is more plainly seen in sections. Eggs which are to be sectioned must be treated with various reagents and it might readily happen that the action of these would produce an artificial space between the cortex and the shell. The existence of this space naturally is, however, made probable by the Berlin blue reaction which shows in sections a distinct and rather broad blue line in the position where the space should be. This is not only evidence of a space, but of a space filled with an albuminous fluid. The perivitelline space becomes very much larger as the eggs come into contact with water and will be dealt with more fully later.

The *egg shell* (z. r. Figs. 9, 10, etc.). The egg membrane or egg shell of the wall-eyed pike, is separated from the cortical layer in the freshly laid egg only by the very narrow perivitelline space. It is usually described as wrinkled in the freshly laid eggs of bony fishes. In the wall-eyed pike the membrane cannot be said to be wrinkled, it merely follows the irregularities of outline of the underlying yolk, so that the entire area of the inner surface of the egg membrane is scarcely greater than that of the outer surface of the cortical layer. In the freshly laid egg the finer structure of the egg shell is not readily made out unless water be added to the eggs. The water causes the disappearance of the cortical drops from the egg and at the same time leads to the enlargement of the perivitelline space, so that the egg shell is more readily examined. The addition of water produces no visible change in the structure of the egg shell except that it makes it thinner. What is here said with regard to this structure applies therefore to any stage of the egg here considered.

In the freshly laid egg, if one examines the shell in optical cross section, it is not difficult to see that it is made up of at least two layers, an external, thinner layer, the external egg membrane, and an inner, much thicker layer, the zona radiata. The external egg membrane is about .002 mm. thick. It is entirely structureless. Its inner surface, which is fitted against the zona radiata, is smooth, while its outer surface is thrown up into numerous minute ridges which appear in optical section as slight pointed elevations of the surface. If the surface of the external membrane is examined in a dim light or as an opaque object, and particularly if one looks obliquely at it, these ridges may be seen running in a wavy course over its outer surface. They give the surface the appearance of being wrinkled. It looks very much as though the outer membrane might have been at first larger than the zona radiata, and might have been shrunken or pressed down against its surface. One would therefore expect these apparent wrinkles to disappear when the egg swells up by the imbibition of water, but they remain and are to be found in eggs that have lain a long time in water. From this fact and from the smoothness of the inner surface of the outer membrane it may be concluded that these are not wrinkles but merely irregular ridges. They make no impression on the zona radiata.

Actual sections (Figs. 18 and 19, e., m.) of the external egg membrane show nothing more with regard to its structure. It does not readily stain in the stains that effect the zona radiata. From its adhesiveness it is probably a mucous layer.

The *zona radiata* has a thickness of about .012 mm. As seen in optical cross section in the living egg (Figs. 9, 10, 11, 16, z. r.) it appears smooth on both its outer and inner borders. It is seen to be marked by radial lines or striations which pass from its inner to its outer surface, and it is from the presence of these that it gets its name of zona radiata. It is not possible to make out the nature of these markings in an optical cross section. If one examines the zona from the surface it is seen to be marked by numerous small circular dots (Fig. 19, b.), which appear either light or dark according to the focus. These dots may be shown by focusing to be the cross sections of fine canals or columns which pass entirely through the zona. It is to them that the zona owes its striated appearance in cross section.

The arrangement of the canals is best made out in surface views and appears at first sight to be quite irregular, but a careful examination shows that over small areas the canals are arranged in parallel rows which run in two directions and cross one another at angles varying between 15 and 30 degrees from a right angle. The size of the areas over which a regularity of arrangement is distinguishable is small and variable. Six to ten pore canals may be counted in a row across one of them. The areas are of various forms, some rectangular, some triangular, and others bounded by curved lines. At their limits they pass without sharp demarcation into neighboring areas. The result is such as would be obtained if a number of persons were to scatter themselves over a field and each independently begin to throw up parallel rows of hillocks running in two directions. Each working out on all sides from a center would soon come upon his neighbors. Each might then try to make his rows harmonize with those of his neighbors where the two met. The result would be an arrangement of the hillocks very much like that of the pore canals of the zona radiata, but somewhat less regular. Where two pore canal areas abut

upon one another the boundary between them often has the form of a semicircle, and it often happens that a large number of such semicircular boundaries follow one another in such a way as to produce a sinusoid curve.

I have spoken of pore canals, but their real nature and the proof that they are actually canals is only to be obtained by a study of thin sections. Such sections should be made in various directions, and should not be more than .005 mm. thick, and some of them should be, if possible, thinner. They may be stained in various ways. If one examines such sections after staining with gentian violet it is found that the material between the canals is stained a deep blue, while the canals remain unstained and appear in a tangential section as colorless circular areas on a dark blue background. If one stains with gentian violet and afterwards with orange, it is found that the canals are stained yellow while the matrix or material between the canals is blue as before. Two things thus become apparent, first, that the canals are not empty tubes, but are filled or plugged with some material and, second, that this material is different from the matrix which lies between the canals. The yellow color given to the contents of the canals by the orange stain is not sufficiently pronounced or sufficiently precise to enable one to determine by its use the exact form and course of the canals, and there is so far not even any evidence to show that the so called canals ore actually such. Much more precise results are obtained by subjecting a piece of the zona radiata together with the underlying cortical layer and the perivitelline space to the Berlin blue reaction. When pieces thus treated are examined from the surface or by means of tangential sections (*i. e.*, parallel to the surface) it is found that the contents of the canals are colored a deep blue, while the material between the canals is unstained. By the use of the gentian violet there are obtained colorless spots (the ends of the canals) on a blue background, while by the Berlin blue reaction there are obtained deep blue spots (Fig. 19b.) on a colorless back ground. By thus staining the contents of the canals while leaving the rest of the zona radiata unstained, it is possible to make out a number of things hitherto obscure. Cross sections of the zona radiata *i. e.*, sections made at right angles to its surface pass lengthwise of the pore canals and enable one to get a side view of them. Such sections (Fig. 19a.) show that the canals are not straight, but that each takes a spiral course from the inner to the outer surface of the zona radiata. Each canal starts at the inner surface of the zona with a broad half spiral turn and then continues in a narrower, closer spiral through about two-thirds the thickness of the zona. It then narrows somewhat abruptly to not more than one-third its former calibre, and continues to the outer surface where it ends in a trumpet-like expansion. Each canal is thus divided into a thicker inner portion (in) and a more slender outer portion (ex). The spiral turns made by the inner portions of the canals at starting do not all pass in the same direction. The result is that they overlie one another, so that unless the section is very thin they obscure one another so much that it is not possible to make out their exact course. If the inner ends of the canals are examined with care it is found that the blue material filling them (Fig. 19c, pv. t.) is directly continuous with the blue material filling the perivitelline space. In other words, the material in the canals is the perivitelline fluid. In some specimens the fluid is found to have passed into the inner ends of the canals without having entirely filled them (Fig. 19c). In such specimens

some canals are filled for a part of their length, while others are not filled at all, and the whole appearance is that of a partial injection of the canals from their inner ends.

The appearance of the canals varies somewhat according to the method by which the egg was preserved. Thus in eggs preserved by Hoffmann's method (Fig. 19c) it is usually not possible to follow the canals to the outer surface of the zona; their delicate outer ends and their trumpet-like expansion are seen with difficulty and the external egg membrane lies close against the zona radiata. In specimens preserved in Perenyi's fluid on the contrary (Fig. 19a) the zona is swollen so as to be half again as thick as by Hoffmann's fluid, the pore canals are readily followed to their outer ends and there is an accumulation of perivitelline fluid between the external egg membrane and the zona radiata (pv. f). The explanation of the difference is probably as follows: Perenyi's fluid swells the zona radiata and increases its thickness while at the same time it lessens the size of the sphere formed by the zona, so as to bring it down close against the cortical layer and cause pressure on the perivitelline fluid. The result of the swelling is to elongate and straighten the pore canals so that the angle between the outer and inner portions is less and the trumpet-like expansion is greater. The canals are thus more easily visible. The result of the contraction is to press upon the perivitelline fluid and force it into the pore canals so as to completely fill them. The pore canals are not only thus filled and rendered visible but some of the fluid frequently flows out of their outer ends and accumulates between the zona radiata and external egg membrane and thus raises the external membrane from the zona radiata and forms an artificial space (Fig. 19a. pv. f).

If one examines sections made parallel to the surface of the zona (Fig. 19b), one sees that in cross section the canals are circular. If the section passes near their inner ends it is found that they have a diameter of between .001 and .0015 mm. and than the distance between them is about one-half their diameter. If the section passes through their outer ends (the section shown in 19b is near the middle) the smaller calibre of the outer portion is at once noticed. It is not more than one-third of the calibre of the inner portion, so that cross sections of individual canals appear as mere dots. The distance between the canals at their outer ends is several times their diameter. This is due not only to the smaller calibre of the canals but to the greater area of the outer surface of the zona as compared to its inner surface.

By the arrangement now described by which the perivitelline fluid passes into delicate canals which traverse the zona radiata, this fluid is enabled to expose an enormously increased surface to the external water. If the external water penetrates into the matrix of the zona radiata it is brought into contact with the fluid of the subzonal space over an area many times greater than the egg itself. A little later it will be shown that this increase of surface of the perivitelline fluid bears an important relation to its probable function.

It is not the intention here to discuss the question of the structure of the egg membranes in bony fishes. The writer has not had access to all the literature on the subject and a review of it is rendered quite unnecessary by the recent careful work of Mark ('90). A few points only will be here touched upon. Mark points out that the evidence upon which the statement is based that the so called *canals* in the zona radiata of fishes are actual perforations is insufficient. He says "The *proof* that the striate

appearance of the zona is due to *pore canals*, although very generally assented to by the most competent observers, especially in recent years, has nevertheless hitherto rested on comparatively slight evidence." The fact that the structures called pore canals are canals at all was denied by André ('75). Mark believes that he has produced additional evidence in having shown that the outer ends of these canals in *Lepidosteus* are penetrated by the root-like prolongations of the villi composing the outer layer of the egg membrane. From thus seeing the outer ends of the canals filled, injected as it were, by some foreign substance Mark correctly concludes that they are canals and is able to establish the fact that they are spiral.

Iu the wall-éyed pike we have now additional and even stronger evidence to the same effect. We see the canals filled from end to end by a material continuous with the fluid in the perivitelline space and apparently identical with it and we see this fluid under certain circumstances forced through the canals. We have also evidence that the canals are spiral, as Mark has described them to be in *Lepidosteus*.

Stockmann ('83) is quoted by Mark and Henneguy as describing in the zona radiata of the trout tooth-like elevations of the walls of the pore canals due to the presence of ridges on their inner surfaces. The observations were made with a one-twentieth Reichert immersion lens. The spiral course of the canals in the wall-eyed pike gives rise to an appearance of teeth along their sides as shown in Fig. 19 a and c. The writer has worked with a 2 mm. Zeiss apochromatic with compensation eye pieces 8 and 12 and has had no difficulty in determining that these apparent teeth in the wall-eyed pike are due merely to the spiral course of the canals. He has not seen Stockmann's paper and does not know whether the teeth described by him are the structures seen in the wall-eyed pike. Stockmann is further quoted as describing fine canals running in the matrix and opening into the pore canals between the teeth. If such structures were present in the wall-eyed pike it would seem that they must be injected by the perivitelline fluid and in that case they must have been readily visible or must at least have given a blue color to the matrix. No evidence was obtained of their existence.

Subzonal membrane. The existence of a subzonal membrane in Teleosts has been both affirmed and denied. In the eggs of the wall-eyed pike after they have lain some time in water, one may often see appearances that are due to the presence of a membrane between the zona and the cortical layer. This membrane seems to be partly adherent to the inner surface of the zona, but is thrown into folds which extend toward the cortical layer into the perivitelline space. The appearance produced by these folds is that of irregular bands or lines running through the perivitelline space near the zona. These bands are sometimes straight, often curved and frequently branched so as to be X shaped. They are transparent, homgeneous and colorless, and are visible owing to their density being greater than that of the perivitelline fluid. I can explain them in no other way than as folds of a structureless membrane. I do not know whether they occur in all eggs, as my attention was only attracted by them at a time when there was not an opportunity of examining many eggs and when the few that remained were not in the best condition.

The same appearance may be seen in eggs that have been treated first with picro-acetic acid and then transferred directly to a mixture of equal parts of glycerine, alcohol and water. The first effect of the latter mixt-

ure is to cause the egg membranes to collapse, but after a short time in the fluids the membranes again become distended. Eggs thus preserved are transparent, the perivitelline space remains clear and the appearance of the living egg is more nearly preserved than by any other process known to me. When these eggs are examined entire one sees lines which are above referred to as produced by folds in a structureless membrane. By stretching the membrane in this way or that one may change the character of the folds by causing them to run in the direction of greatest tension. The egg membranes may be removed and pieces of the subzonal membrane pulled away from the inner surface of the zona. Such pieces are found to be adhesive and to roll up easily. Under the microscope they appear homogeneous and between .001 and .002 mm. thick and covered with the granular precipitate from the subzonal fluid. I was uncertain whether the membrane contained pore canals. The same membrane may be seen in sections of eggs preserved by other methods. It appears here structureless, at least I cannot see pore canals in it. The folds seen in surface view are plain in sections. Sometimes the membrane lies close against the germinal disc or cortex, while in other places it adheres to the zona radiata.

There can be no doubt as to the existence of this membrane in this case. I have not found it in unfertilized eggs protected from contact with water, and it may be formed by the egg under the stimulus of fertilization or of water. On the other hand it may be separated from the zona radiata under the same conditions. The matter needs further investigation.

The micropyle is the opening through which the spermatozoön enters the egg. In the freshly laid egg of the wall-eyed pike it is difficult to find it without the addition of water. When the egg has lain a short time in water there may be seen on the side opposite the germinal disc and directly over the middle of the disc, a saucer-like depression on the outer surface of the egg membranes (Figs. 9, 10, 16, my.). From the middle of the bottom of this depression may be seen a funnel shaped excavation which has its apex directed inward and passes about half way through the zona radiata. It is the micropylar funnel (Fig. 23, my. f.). From the apex of the funnel there proceeds a delicate canal, the micropylar canal, which passes through the remainder of the thickness of the zona to open on its inner surface (Fig. 23, my. c.). The micropylar canal opens at the apex of a conical projection of the zona (Fig. 20, my. e.) and in some specimens that I have examined it seemed to expand so as to end in a slight funnel shaped enlargement. It is difficult to be sure of the accuracy of this observation. Before the egg has touched the water the conical elevation at the top of which the micropylar canal opens is imbedded in the germinal disc (Figs. 9 and 10) and cannot then be seen. After the egg has lain in water for three or four minutes the zona radiata is raised up from the surface of the germinal disc by the accumulation of water beneath it, and the conical micropylar elevation is pulled out of the germinal disc so as to be readily seen (Fig. 16). No attempt has been made to study the micropyle in sections, but I have come upon it once by chance. In this section it was seen that the zona radiata was thinner for a short distance on every side of the micropyle than elsewhere. Doubtless this thin area of the zona, in the center of which the micropyle lies, corresponds to the saucer-like depression seen on the surface of the living egg. In this section the micropylar funnel and canal were visible, but their appear-

ance was the same as in the living egg. The micropylar elevation did not appear.

One may get a crude notion of the micropyle by punching a hole in a piece of cardboard with some conical instrument, such as the point of a lead pencil. The cardboard represents the egg membrane and the opening the micropyle, and it will usually happen that on the side opposite that against which the pencil is forced, the cardboard is thrown up into a conical elevation, at the top of which is the hole that has been made. This elevation corresponds to the micropylar elevation which is of importance in later stages.

The egg of the wall-eyed pike then, as it leaves the fish and before it comes in contact with water (Fig. 9), is a soft, irregularly spherical, yellowish body one-nineteenth of an inch in diameter and bathed by a small quantity of an alkaline albuminous fluid. It consists of a central yolk, inclosing a single large yellow oil drop and itself surrounded by a cortical layer. The line of separation between cortical layer and yolk is not sharp. The cortical layer is thickened on one side to form the germinal disc. It consists of a network of cytoplasm threads inclosing hyaloplasm and incloses numerous albuminous cortical drops. The germinal disc contains the nucleus which is in one of the phases of karyokinesis. Outside the cortical layer and separated from it by a very narrow space are the egg membranes, an inner zona radiata pierced by numerous spiral pore canals which pass quite through it and an outer, structureless, mucous, external egg membrane. The pore canals of the zona are filled with an albuminous fluid which is continuous with the fluid in the perivitelline space. Over the middle of the germinal disc is the micropyle, which lies at the bottom of a saucer-like depression and consists of a micropylar funnel and a micropylar canal, the latter opening internally at the top of a conical micropylar elevation which is received into a depression in the germinal disc.

Such an egg may be compared to an ordinary cell. It differs from other cells in its great size, which is probably thousands of times greater than that of any other cell in the body. This difference is brought about by the presence in the egg of the yolk, the food material upon which the developing fish must be nourished until it is large enough to care for itself. This food material is stored up in the middle of the egg cell, and the protoplasm of the cell is consequently forced to the surface where it forms the cortical layer. (Compare Figs. 1 and 9; 1 is magnified many more times than 9.) Not all the protoplasm is thus forced to the surface, since a few cytoplasm threads are to be found in the superficial layers of the yolk. The cortical layer moreover is thickened on one side in the region where the nucleus is, and this thickening, the germinal disc (Fig. 9, g. d.) doubtless owes its existence to the presence of the nucleus. The nucleus (nu.) is in the process of karyokinesis, as it may be in any other cell. Finally the egg cell is inclosed in a peculiar cell wall, the zona radiata (z. r.). It is possible that the outer egg membrane is also a part of the cell wall, but this is uncertain. We may thus compare the egg cell point for point with an ordinary cell and see that its peculiarities are to be referred to the work that it has to do, the work of furnishing food and protection for the young fish.

B.—BEHAVIOR OF THE FRESHLY-LAID EGG UNDER THE ACTION OF WATER.

When the eggs of the wall-eyed pike are placed in water, a number of changes are visible to the naked eye. The eggs adhere to any object with which they come in contact. The adhesion is at first slight, but if the eggs are not disturbed it becomes gradually firmer, until at the end of half an hour any attempt to free the egg from the object to which it has adhered is likely to result in bursting it. The adhesion is undoubtedly due to the action of the water on the external egg membrane. The water appears to gradually harden the external membrane which thus looses its adhesive qualities. If the eggs are kept continually in motion so as to break up every slight adhesion as soon as it is formed, they may, after an hour or so, be left to stand without fear of their again adhering. The eggs adhere more firmly to a smooth surface than to a rough one probably because smooth surfaces afford larger unbroken surface of contact. That the adhesion is due to the action of the water and not to any solids or gases dissolved in the water, is shown by the fact that the adhesion is just as great in distilled water as in lake water and is the same in lake water that has been vigorously boiled to expel gases that it is in unboiled lake water.

A second effect of water visible to the unaided eye, is that the egg rapidly looses its irregularity of form and softness and becomes larger, regularly spherical and hard to the touch. This process is called "filling" of the egg and is due to the absorption of water, so that during the process as Miescher ('80) has shown the egg actually increases in weight. An egg before it has been in water is soft and lacks elasticity; it has the physical properties of a ball of putty. An egg after it has been for half an hour or more in water is hard to the touch and elastic. It is almost impossible to crush it by compressing it evenly between the ball of the thumb and fore finger. If thrown it bounds like a rubber ball. The egg after it is filled is therefore much more difficult to injure than before it was filled.

Much more is to be made out concerning the effect of water on the egg by examining it under the microscope during the process of filling and by comparison of sections and other preparations made from eggs before and after filling. In order to study the living egg the following device was resorted to. A dozen or more eggs were arranged in rows on the bottom of a watch glass (a solid watch glass is preferable) in such a way that they do not touch one another. While arranging the eggs they may be lifted on the point of a scapel and shoved about in the watch glass by the same means, but they should not be grasped between the jaws of a pair of forceps nor subjected to any other pressure, lest the cortical layer be injured and the yolk escape. When the eggs are arranged the watch glass is placed under the microscope, an egg focused and water added. The addition of water causes the eggs to adhere to the watch glass in the position in which they were placed, and it is easy to pass from egg to egg in any row and to locate any egg by its number in the row, and so be able to find it readily again. The eggs were studied by the use of Zeiss's 16 mm. apochromatic lens, with various eye pieces. No cover glass was found necessary.

The first change that attracts attention is the disappearance of the cortical drops. The drops disappear rapidly so that at the end of two or three minutes there are usually none of them to be found. (Compare Figs. 9 and 16, or 10 and 11). It is difficult to say from a study of the living

egg what becomes of them. By focusing carefully on a single drop one may see that its dark borders become gradually less distinct, the drop itself becomes paler and fades from sight. From the time the border of the drop becomes indistinct until it has entirely disappeared is usually about two seconds. In eggs that are attached by one surface to glass it is noticed that the drops disappear first from the exposed upper surface, while on the lower surface which is protected from the water by its adherence to the glass, they remain for many minutes. This shows that the disappearance of the drops is due to the action of the water. Whether they are dissolved in situ by the water or expelled into the perivitelline space and then dissolved is difficult to determine. In one case by focusing on a drop which lay near the middle of the optical section of the egg I was able to see it discharged into the perivitelline space, where it almost instantly disappeared by solution. I have never been able to verify this observation, so that it is probably to be explained by supposing that in this case the cortical layer was injured and the discharge of the drop abnormal. Certainly if the drops are regularly discharged as such into the perivitelline space one ought to see it. The drops disappear in ordinary lake water, but if the water used is very slightly alkaline the drops do not disappear.

From the above facts, the disappearance of the cortical drops only upon actual contact with water that is not alkaline, and the failure to see them discharge in the living egg, we might surmise that they are *not* discharged into the perivitelline space, but are dissolved by the water in situ. Sections give some further light on the subject.

A second effect visible in the living egg under the microscope is that the perivitelline space is enlarging, or one might say it is forming, since before the addition of water to the egg the space is a mere chink between the zona radiata and the cortex. Now the space enlarges rapidly and on all sides at once. The enlargement is due to the passage of water through the egg membranes and its accumulation in the perivitelline space. It was observed by Ransom ('66) that the water passed in the stickleback through the micropyle, but that in other forms the water probably passed in through the egg membranes at all points with equal rapidity. In the wall-eyed pike one may watch in vain at the funnel of the micropyle for any indication of a current of water setting in there. There is no movement of spermatozoa or other small particles in the water that would indicate a current through the micropyle. The amount of water that passes into the perivitelline space is so great that if it all passed through the micropyle the rate of flow must be enormous. It would seem to be a physical impossibility for so much water to pass through so small an opening in so short a time. If the water passed in through the micropyle the perivitelline space ought to be seen first at the micropyle and ought then to extend in all directions about the egg. As a matter of fact the perivitelline space appears over the whole surface of the egg at about the same time. It often happens that it appears a little later in the region of the micropyle than elsewhere.

Calberla ('79) has furnished decisive evidence on this point in the eggs of the lamprey eel. He placed some of the eggs in water that had been colored blue by induline and as the eggs filled he found that the blue fluid had passed into the perivitelline space and formed a uniform layer everywhere between the zona radiata and the yolk. He then transferred the eggs to pure water. If now the water passed in through the

micropyle, the result must be either that the blue fluid would be forced to that part of the perivitelline space on the side of the egg opposite the micropyle while the water would occupy that part of the space in the region of the micropyle, or else that the two fluids would be thoroughly mixed. If on the contrary the water passed in through all parts of the egg membranes at the same time then there would be formed a layer or shell of water everywhere in the perivitelline space just beneath the zona radiata, and within this shell of water must be the blue fluid. The experiment showed that the fluids were arranged in the second way and thus proved that they had entered the perivitelline space on all sides at the same time and not through the micropyle.

It has been said that the disappearance of the cortical drops and the formation of the subzonal space takes place at the same time. The cortical drops have disappeared at the end of three or four minutes, but at that time the perivitelline space is still very small. It continues to enlarge for about half an hour, the rate appearing to depend somewhat on the temperature, but at the end of half an hour or an hour the space is fully formed. Although the formation of the space goes on after the cortical drops have been dissolved, there is nevertheless a close connection between the two phenomena and the formation of the space is wholly dependent on the solution of the drops. There is an interdependence in *rate*. If by reason of low temperature or for other cause the cortical drops disappear slowly the perivitelline space forms slowly. The disappearance of the drops is accompanied or immediately followed by the appearance of the perivitelline space, so that there is an interdependence in *time* between the two phenomena. It sometimes happens that the cortical drops do not disappear under the action of water. This is frequently the case in eggs from unripe fish or from fish that have been kept in confinement under unfavorable conditions. In such cases there is no formation of a perivitelline space. On the other hand the character of the water may be such that it does not dissolve the surface drops or dissolves only part of them. This is true of water that contains a trace of an alkali. Thus water which contains a very small proportion of milt is distinctly though feebly alkaline and in such water the cortical drops are either not dissolved at all or only a part of them is dissolved, and the eggs either do not form a perivitelline space or form only a very small space. From this intimate connection between the formation of the perivitelline space and the disappearance of the cortical drops we may conclude that the solution of the drops is necessary to the formation of the perivitelline space.

When the perivitelline space has formed and the egg is "filled" the fluid contained in the space has the appearance of water and has been usually regarded as such. It has a distinct, though not strong, alkaline reaction and, when evaporated, leaves a considerable non-crystalline residue. Under the microscope it appears in the egg at first sight entirely clear and free from solid particles. I have not examined it under the microscope after removal from the perivitelline space but only in the space in the living egg. This examination was made for the purpose at first of seeing whether it was possible to detect in the subzonal space the presence of numerous spermatozoa as they have been described by Kupffer ('77). By thus searching carefully through the perivitelline fluid there were frequently found minute granules of almost precisely the size of the heads of the spermatozoa that were seen lying outside the zona radiata. These granules were in motion moving here and there and at the same time

oscillating so that the motion resembled very closely that of the head of a slowly moving spermatozoön. Under the power that it was possible to use and with the obstruction to clear vision presented by the zona radiata, one could scarcely expect to see the tails of the spermatozoa. I was therefore for a long time inclined to think these granules the heads of spermatozoa. I was able to find them not only in the part of the perivitelline space opposite the germinal disc but in all parts of the space. They were visible as soon as the perivitelline space had formed and in positions which it would be impossible for them to have reached from the micropyle, so that if they were spermatozoa they must have penetrated the zona radiata at all points in great numbers and very rapidly. The improbability of this and the fact that although most of them were of the size of the head of a spermatozoön, yet some were larger and few several times as large, led me to doubt as to the validity of this conclusion. I was finally led to an examination of unfertilized eggs, which had been carefully protected from any contact with spermatozoa, and there found the same granules moving in the same manner. They are probably therefore either granules of protoplasm torn off possibly by the currents produced in the dissolution of the cortical drops, or they may be granules of yolk material that have in some way escaped into the perivitelline space. Their movements are wholly physical and are doubtless due to osmotic currents. They prove that this fluid in the perivitelline space is not at rest but is on the contrary in constant motion.

The perivitelline fluid mixes readily with water without producing any precipitate or any milkiness of the water such as was described by Solger ('85) and such as would occur in the wall-eyed pike if these granules were yolk granules and were present in sufficient quantity. They may be yolk granules not sufficiently abundant to produce turbidity.

The perivitelline fluid undoubtedly serves a purpose in the economy of the egg in that it keeps the egg membranes tense and thus affords protection to the parts within. The proof of this will be forthcoming presently. It undoubtedly also serves to transmit from the surrounding water to the cortical layer the oxygen gas which the egg needs, and to transmit the carbonic acid gas from the egg of the external water. It thus necessarily associates with the function of protection to the egg, the further function of serving as a go-between from the egg to the water in which the egg lies. In what manner it probably does this will appear later.

The question now arises as to whether the perivitelline fluid is in any way necessary to the egg except as affording protection. Can the egg live in the earlier stages if the shell and perivitelline fluid are removed from it? In the eggs of most bony fishes it is practically impossible to remove the shell and the perivitelline fluid in the early stages, *i. e.*, before segmentation has set in. Attempts to do this in the wall-eyed pike have invariably resulted in the injury to the egg. Even when, in slightly later stages, it is possible to remove the shell it is found that the egg is too delicate to bear its own weight and that after a short time the cortical layer is ruptured and the egg goes to pieces. Probably the same statements hold for the eggs of nearly all bony fishes. In the egg of the common sucker (*Catostomus teres*) I have found that it is not difficult to remove the shell and the rather thick perivitelline fluid by means of fine scissors and forceps.

The record of an experiment in which this was done is as follows: The

eggs were taken on April 10, 1892 at 11:30 a. m. and were fertilized artificially. On April 12 at 10 a. m. the yolk was found to be about half covered by the blastodern. The shell and perivitelline fluid were then removed from a number of eggs which were then put into a dish by themselves in running water. In some of the eggs a large opening was cut in the shell and the perivitelline fluid was washed out through this, but the eggs were not removed from the shell. On April 16 at 4 p. m. well developed embryos with optic vesicles and lens were found on the eggs. The embryos were further advanced in development than those in unopened eggs in another dish, but this may have been due to a difference of temperature. Some of them had been attacked by fungus. The healthy embryos were removed to another dish and on April 17 one of them had escaped from the shell and voluntary movements were detected in others. These embryos continued to develop normally until the whole yolk was entirely absorbed, when they died of starvation.

We thus have good evidence that the only necessary function of the perivitelline fluid in the stage experimented on (and of the shell) is that of protection, since eggs deprived of both develop perfectly well if they are protected by placing them in a dish by themselves. The function of transmitting oxygen and carbonic acid gas, which the perivitelline fluid assumes, is one forced on it by its position, and one for which it does not appear that it has any peculiar adaption. Probably any other harmless albuminous fluid having about the physical properties of the perivitelline fluid would serve as well in its place.

So far, I have spoken of the effect of water on the unfertilized egg as seen in the living egg in producing the solution of the cortical drops and the formation of the perivitelline space. These changes are accompanied by others. The accumulation of water under the egg shell causes the latter to be raised up and to be stretched and thinned. In the freshly laid egg the shell lies close against the cortical layer and adapts itself to whatever form the contained yolk may take. Both shell and yolk lack elasticity and may be moulded within certain limits into other forms than the sphere. The shell is not thrown into folds, as it is commonly stated to be in other bony fishes. When the shell is distended by the accumulation of the perivitelline fluid the distension is not to be thought of as a mere expansion of the originally collapsed shell, such as one might produce by blowing into a collapsed bag of leather as a glove finger. The shell is not merely distended; it is stretched and enlarged so that it becomes thinner in the process, as does a rubber bag when inflated with air. The stretching and thinning of the shell, once brought about, is permanent and the shell retains the size and form given to it. So far as the effect on the shell is concerned the process is the same as that which takes place when a fresh bladder is inflated with air and then dried. As the air is forced into the bladder its walls yield, stretch and become thinner and the bladder enlarges. If the air is allowed to escape the bladder again contracts, but if the air is not allowed to escape and the bladder is dried, it retains the form and size imparted to it by the air within it and does not again collapse. It is the same with the shell of the wall-eyed pike egg. Stretched and thinned by the accumulation of water in the perivitelline space it retains the form thus given it, and if punctured does not again collapse.

It is difficult to determine quantitatively the amount of thinning of the membranes during the process. Sections made of the eggs preserved in Hoffmann's fluid before the formation of the perivitelline space give a

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total thickness of .017 mm., while those made from eggs after the formation of the space give a thickness of .012 mm. Here the action of the reagents has probably been to decrease the first measurement, since it causes a slight enlargement of the perivitelline space of eggs that have not come into contact with water. Unfortunately no accurate measurements were made on the living egg though the thinning was many times noticed, and its existence determined at least once by projecting with a camera an optical cross section of the shell before and after the formation of the space. The thinning appears by a comparison of Figs. 10 and 13, or 9 and 16.

Another result of the action of water, and one visible in the living egg, is the increase in size of the germinal disc. When the egg leaves the fish the disc exists, as already described, as an irregularly thickened patch on one side of the cortical layer. There may be two of these patches and from them thickened strands of cortical substance pass toward the equator of the egg. In an optical section of the egg (Figs. 9 and 10) the disc is a crescent-shaped thickening of the cortical layer and appears to cover one-third of the circumference of the egg, though this great extension is no doubt due in part to the radial thickenings mentioned above. Two minutes after the egg has touched the water (Fig. 11) the germinal disc (g. d.) has become of about two-thirds its former breadth and nearly twice as thick. This change is due to a flowing of the protoplasm of the cortical layer into the disc so as to increase its volume. It is possible that the cytoplasm contained in the yolk contributes slightly to this increase of volume. An examination of the cortical layer stripped from a preserved egg at this time shows that the thickenings which radiated from the edges of the germinal disc have been withdrawn. They have doubtless been taken up into the disc.

At the end of seven minutes from the time the egg touches the water the germinal disc (Fig. 12), though of about the same breadth, is half again as thick as at two minutes. The perivitelline space has now a width about one-eighth the diameter of the oil drop. At the end of an hour (Fig. 13) the perivitelline space has increased to a width about one-third that of the oil drop, but the germinal disc remains of the same size as before. When removed from the yolk it has now the form of a saucer or a watch glass, the concave surface of which is fitted against the yolk. It is thickest at its middle and becomes gradually thinner towards its edges where it passes into the cortical layer.

At the end of two and a half hours (Fig. 14) the perivitelline space has an average width nearly one-half that of the oil drop and the germinal disc has changed shape. Its breadth is now diminished by about a third and its thickness is nearly doubled. It is no longer concave on its lower surface like a saucer, but flat, while its free surface is arched like a part of the surface of a sphere. The surface of the yolk against which it rests is flattened and adapted to the now plane base of the germinal disc. At its borders the surface of the disc is continued smoothly into the surface of the cortical layer covering the adjacent yolk, so that in the optical section the outline of the disc and yolk taken together is nearly a circle (Fig. 14) and the disc forms scarcely any projection on the surface of the yolk. The disc thus has the form of a part of a sphere, the radius of which is only slightly smaller than the radius of the yolk.

At the end of three hours (Fig. 15) the perivitelline space is of the same size as at two and a half hours, but the germinal disc has changed. It still has the form of a portion of a sphere with one flat side, but of a

sphere whose radius is somewhat less than two-thirds the radius of the yolk sphere. The yolk is flattened on one side as before and the germinal disc, now almost hemispherical, has its flat side fitted against the flat side of the yolk. The result is that the germinal disc now forms a decided protuberance on the side of the yolk, a protuberance large enough to be seen with the naked eye. The surface of the germinal disc no longer passes smoothly into that of the cortical layer covering the adjacent yolk at its borders, but there is a triangular groove about the egg at the edge of the germinal disc (Fig. 15, gr.).

The bulk of the germinal disc, when it has thus taken on its final form, is much greater than its bulk in the freshly laid egg (compare Figs. 11 and 15), and the additions have been mainly at the expense of the other portions of the cortical layer (compare Figs. 9 and 16).

It is to be noted here that this formation of a germial disc does not take place unless the cortical drops are dissolved and that it takes place only imperfectly when only a part of the cortical drops is dissolved. The reason for this seems to be that the protoplasm is burdened by the presence of the drops and when loaded with them is not able to draw itself together into a disc. Thus the solution of the cortical drops becomes a matter of great consequence for the future welfare of the egg. Eggs in which any considerable number of them remains undissolved and in which the germinal disc is not fully formed do not develop further.

The last change to be noticed in the living egg as a result of the addition of water, is a slight decrease in the volume of the egg proper. This decrease in volume results, as it does in so many other eggs (see below), from the solution of the surface drops. While the whole egg is increasing in volume by the absorption of water, the cortical layer and its contents, the yolk, are diminishing in volume. The substance of the cortical drops passes from the cortical layer into the perivitelline space and the volume of the cortical layer is diminished by so much.

There is no evidence that the egg of the wall-eyed pike contracts or shrinks through any vital activity of its protoplasm. The whole process seems to be rather a physical one, the solution of the cortical drops. Knowing the number of cortical drops in a unit of area and their average size it would not be difficult to calculate the amount of shrinkage due to this cause, and to compare it with the amount actually observed, but this has not been done. Besides this actual shrinkage of the egg body, there is an apparent shrinkage with which it has possibly been sometimes confounded. Before the egg fills, the egg body when it lies on a flat surface is forced to bear its own weight, and it consequently flattens somewhat, just as does a sphere of soft putty or dough when laid on a hard, flat surface. Such an egg examined from above appears to be larger than it really is, since its diameter parallel to the surface on which it lies is greater than its diameter vertical to that surface.

When the perivitelline space is formed the egg body nearly floats in the albuminous fluid which fills that space. It is supported on all sides, and only a small part of its weight probably rests on the egg shell below. The support afforded it by the egg shell is, moreover, not that of a flat surface, but a concave surface. The result is that the egg body becomes more nearly spherical, the diameter parallel to the surface on which it rests is more nearly equal to the diameter vertical to that surface, and when seen from above the egg body conse-

quently *appears* smaller. It appears to have shrunken while it has in reality merely changed shape.

We thus see in the living egg under the microscope the following changes, due to the action of water:—The disappearance of the cortical drops, the formation of the perivitelline space, the thinning of the egg-shell, the increase in size and the changes of form of the germinal disc and the shrinkage of the egg body. All these changes may be seen by a comparison of Figs. 9 and 16.

Sections of preserved eggs show very much the same things with regard to the effect of water on the egg that are to be observed in the living egg. Sections through the cortical layer outside the germinal disc show at once the absence of the cortical drops. When the drops are present the cortical layer has a thickness equal to the diameter of the drops (Fig. 9), but now that they are absent the cortical layer has a thickness which is not more than one-third the average diameter of the cortical drops (Fig. 16). To this reduction in thickness of the cortical layer by the withdrawal from it of the cortical drops is to be attributed the shrinkage in volume of the egg body.

Preserved eggs show as already pointed out a precipitate in the perivitelline space. The fluid in this space is not then pure water but water containing some substances in solution. If this precipitate be subjected to the Berlin blue reaction or if sections showing it be subjected to this reaction, it becomes intensely blue. It is then seen to be made up of large numbers of minute granules, similar to those making up the cortical drops after the action on them of reagents. These granules become blue under the Berlin blue reaction and are then not to be distinguished from the granules composing the cortical drops of an earlier stage, or from the granules making up the blue mass which fills the pore canals of the zona radiata. We thus conclude that the albumen composing the cortical drops is not only dissolved by the water which penetrates the zona radiata but that it is carried by the water into the perivitelline space and is retained there. It is therefore a substance that does not dialyze since it does not pass through the egg shell through which water passes readily.

We may get additional evidence of the identity of the material of the cortical drops with that in solution in the perivitelline space by the use of the orange stain. One sometimes gets sections passing through the germinal disc, the perivitelline space and the egg shell. In some such sections of eggs taken at the proper time the germinal disc or the adjacent cortex still contains a few cortical drops. If these sections are stained with orange it is found that, as before, the cortical drops and the hyaloplasm of the cortex become of a yellow color. At the same time the precipitate in the perivitelline space is stained yellow and the material filling the pore canals becomes of the same color. We thus get in one section evidence that these substances are the same, that the albumen of the cortical drops is accumulated hyaloplasm, that this albumen is dissolved in the water of the perivitelline space and that it (or an identical fluid) penetrates thence into the pore canals. I have in one case seen in a section of an unfertilized egg before contact with water strands extending from the cortical drops into the perivitelline space (Fig. 18). The appearance is as though the fluid used (Hoffman's) had partly dissolved the drops and as though the dissolved portions were passing in radial streams into the perivitelline space. If it is true that the hyaloplasm is

identical with the cortical drops there is here afforded what is probably a unique opportunity to study the chemical and physiological properties of hyaloplasm since it may be collected, as perivitelline fluid, in considerable quantities, in a pure condition, from the eggs of the sucker.

In sections also one may get evidence of the thinning of the zona radiata as it is stretched to accommodate the accumulation of fluid in the perivitelline space. The accumulation of the protoplasm to form the germinal disc may also be followed in the sections and in other preparations of preserved eggs, but little is thus added to what is learned from a study of the living egg.

The effect of water on the freshly laid egg of the wall-eyed pike may thus be briefly summarized. It causes the external egg membrane to become adhesive, but this power is lost after a time. It penetrates the egg membranes and dissolves the cortical drops, usually in the course of three minutes. The albumen of the cortical drops is carried by it into the perivitelline space and remains there in solution. This solution passes into the pore canals of the zona radiata. The water continues to accumulate in the perivitelline space until the space has reached a breadth of about two-thirds that of the oil drop. By this process the egg membranes are stretched and rendered thin and tense and the whole egg becomes hard to the touch and elastic. At the same time there is a slight shrinkage of the egg body owing to the extraction of the cortical drops from the cortex and there is a rounding up of the egg body so that it assumes more nearly a spherical form. Finally the germinal disc increases in thickness and gradually takes on the form of the segment of a sphere with one side flat and the other arched.

That the egg is a cell differing from other cells principally in containing a large amount of food yolk has been already pointed out, it remains to show as far as possible the use to the egg of the cortical drops, the cause of the filling, the use of the pore canals, of the zona radiata, and of the external egg membrane.

After the material of the cortical drops has been dissolved in the water of the perivitelline space we have in that space the albuminous perivitelline fluid, and it has been shown that this fluid serves to keep the egg membranes tense and so protects the egg, but it has not been shown how the fluid acts to do this. It is a well known fact that certain membranes called dialyzers, allow water to pass through them and allow any crystalizable substance like salt or sugar to pass through in solution in the water. Dialyzers do not allow most non-crystalizable substances, such for instance as the white of an egg to pass through them. Thus if one dilutes an, albumen, like the white of an egg, with water, and places it on one side of a dialyzing membrane and places on the other side a solution of salt in water, it will be found after a time that some of the water containing salt has passed through the dialyzer into the solution of albumen, but that none of the albumen has passed through into the side containing the salt solution. The passage of water through the dialyzer in both directions continues until there is as much salt on one side of the membrane as on the other, but no albumen passes through. The rule with regard to the passage of water through a dialyzer is that the water passes most rapidly onto that side of the dialyzer on which there is the denser solution. Thus if there is a solution of egg albumen on one side of a dialyzer and water on the other more water passes over to the side on which is the egg albumen than onto the opposite side, and there is an accumulation of water on the side on which the albumen is.

This may be illustrated by the following very old experiment. Remove the shell from one end of an egg in such a manner as to leave the thin membrane which lines the shell in place and unbroken. Make an opening in the opposite end of the egg through both the shell and the shell membranes, and insert a small glass tube which should extend down into the albumen. Cement the tube in place by plaster of Paris and after the plaster has set place the egg in a tumbler of water with the tube projecting upward. After a time it will be seen that the egg albumen is rising in the tube and it continues to rise slowly and finally overflows at the top of the tube. The explanation of this is that the shell membrane which separates the albumen from the water in the cup is a dialyzer and since the albumen is a much denser solution than the water a much larger volume of water passes through the shell membrane into the egg than passes in the opposite direction into the cup. The result is that the albumen is forced up the tube and overflows at the top. The albumen would thus continue to rise in the tube until it had formed a column high enough so that its weight produced pressure enough in the egg to force back into the tumbler from the egg as much water as entered the egg. When the column has risen thus high, an equilibrium would be established and maintained. A similar result may be obtained in a different way. One may take a bladder and fill it with a solution of albumen and then place it in water. The water passes into the bladder more rapidly than it passes out and the bladder speedily becomes distended by the accumulation of water within it. This goes on until the distension of the bladder produces within it sufficient pressure to force out as much water as enters and thus as equilibrium is established and maintained. If one presses strongly on the bladder water is forced out in excess of that which enters and the bladder partly collapses, when the pressure is removed water again passes into the bladder more rapidly than out and the bladder is distended.

The condition of things in the egg of the wall-eyed pike is practically identical with that in the case of the bladder just referred to. The egg membranes form a bag the walls of which constitute a dialyzer. Within this bag is an albuminous fluid. The water consequently passes by osmosis more rapidly into the bag than out and it becomes distended. The albumen contained in the egg membranes always remains there. If any pressure is brought to bear on the egg some of the water may be forced out but the albumen remains within and as soon as the pressure is removed the water re-enters and the egg again becomes hard and tense.

The function of the perivitelline fluid then is to keep the egg shell tense by keeping it constantly full of water. The result is that the egg is protected. It is difficult to injure an egg that is fully filled, while a partly filled egg may be crushed or cut with the greatest ease.

The perivitelline fluid being in the position in which it is between the egg which needs oxygen and the water which contains oxygen must serve as a carrier of oxygen (and of carbon dioxide) from one to the other. That it does this passively has been shown, since the egg can exist without the perivitelline fluid if it is supplied with plenty of water. In its work of transmitting oxygen from the surrounding water to the egg body (to the protoplasm) the perivitelline fluid is greatly aided by the currents which are circulating in it. The existence of these currents is demonstrated by the movements of the granules of the fluid. They might perhaps be demonstrated by the use of colored liquids such as were used

by Calberla ('77). This exchange of gases or water between the perivitelline fluid and the external water must be greatly aided by the enormously increased surface which the presence of the pore canals enables the perivitelline fluid to expose. If these canals did not exist the area exposed by the perivitelline fluid would be that of the inner surface of the zona radiata, but by the presence of the pore canals and by their spiral course this area is increased to many times that of the zona radiata. Not only is the surface thus increased but the perivitelline fluid is thus brought into much closer contact with the water than would otherwise be possible. We must of course assume that the water in its turn penetrates readily into the matrix between the pore canals.

In the case of the egg in rapidly running water it may be that this increase of surface is not necessary and that an area equal to that of the zona radiata would be sufficient for their purposes. If the eggs are brought into unfavorable conditions, into stagnant water containing little oxygen, the increased surface afforded by the pore canals becomes at once of the greatest consequence, since it enables them to exist where they might otherwise perish. We may thus perhaps explain the fact that many fish eggs will develop normally in open dishes of water if the water is changed but two or three times daily.

The *external egg membrane* is of different chemical composition from the zona radiata, and from its behavior toward water is probably a mucus. It serves to close the pore canals externally. It sometimes happens in sections that one cuts through the egg membranes in places where the external membrane has been accidentally removed before or during the preservtion of the egg. In one such place it could be seen that the fluid of the perivitelline space had escaped in considerable qantity and lay on the outer surface of the zona radiata. It could be traced from this place through the pore canals to the perivitelline space. From this we may conclude that the external egg membrane serves to close the outer ends of the pore canals and keeps their contents from contact with the outer water. It is known that mucus is a substance that resists decay or is unfavorable to the growth of bacteria. Thus the mucous coverings of the eggs of frogs and toads enables those eggs to develop with safety in impure water. If the external egg membrane of the wall-eyed pike is, as it seems to be, mucous, it would serve the same purpose in warding off decay, and in protecting the egg against the attacks of bacteria and fungus.

C.—HISTORICAL AND CRITICAL ON FILLING OF THE EGG.

The process of filling of the eggs of bony fishes is so striking a phenomenon, changing the soft egg to an elastic and resistent sphere, that it can scarcely have failed to attract the attention of the earliest observers of these eggs.

Rathke ('32) has given the first account of it that I have been able to find in the literature. He mentions (p. 394) the fact that in trout upon placing the egg in water, the yolk draws itself together into a sphere and is separated from the shell over most of its surface by a fluid clear as water.

Von Baer ('35), three years later, in Cyprinus describes the increase in size of the egg (to twice its former size) as due to the swelling in water of a thin albuminous layer (zona radiata) which covers it when laid. The surface of this swollen albumen then hardens to form the egg shell (zona radiata), while its deeper portions become fluid (perivitelline space).

Von Baer was here evidently unconsciously attempting to reconcile his observation with what was then known of the matter in the frog.

Rusconi ('36) gives the first clear account of what takes place. In *Perca* and *Cyprinus* he describes a thin membrane which lies close against the egg while the latter is in the ovary. When the egg passes into the water this membrane is raised up from the yolk by the accumulation of water beneath it, so that the egg is able to turn about inside its shell.

Vogt ('42) describes the filling of the egg of the European whitefish (*Coregonus palcæ*). He considered the privitelline fluid to be water simply, since he was not able to cause any precipitate in it by chemical reagents, and since it behaved like water in coagulating the yolk. He thought its penetration into the egg was to be explained by the capillary action of the tubes (pore canals) of the zona radiata. It is to be noticed here that while the capillary action of the pore canals might cause the water to fill the canals and to fill a small space between the zona radiata and the cortex, it is difficult to understand how it could do more than this, since after a small amount of water was once in the perivitelline space the capillary action of the pore canals would be exerted as much in one direction as in the other and would tend as much to empty the perivitelline space as to fill it.

Costé ('47), following von Bear, speaks of the perivitelline fluid as albumen, while

Lereboullet ('54) considers it to be water and states that it is not albumen.

Reichert, B. K. ('56) noted the formation of the perivitelline space in the pike (*Esox*) and added the important observation that the fluid yielded a precipitate upon the addition to it of nitric acid. This is the first proof that the perivitelline fluid is not water.

Ransom ('66) gives the first description of the cortical drops. He describes them as droplets of a yellowish color and less refractive than oil. placed near the surface of the egg, and says that they render the unimpregnated egg more opaque than the impregnated egg. When discharged into the water by the rupture of the egg they become pale and disappear. Ransom also describes the disappearance of the cortical drops when water is added to the egg and the formation at the same time of the perivitelline space (breathing chamber). He thinks the formation of the breathing chamber is due in part to the contraction of the yolk, and that the disappearance of the cortical drops is due to the action of water, since they disappear first where water first comes in contact with them and disappear more slowly in eggs that are scantily supplied with water. Ranson notes further that the eggs of *Gasterosteus* do not fill under the action of water alone but only when milt is added to the water. The meaning of this probably is, as pointed out by Ransom and later by Kupffer, that the external egg membrane in this form protects the egg against the action of water, but that this membrane is dissolved or modified by the addition of milt to the water in such a way that it becomes permeable.

Boeck ('71) seems, according to Kupffer's account, to have seen and described the cortical drops.

Owsiannikow ('72) noted the filling of the egg of *Coregonus lavaretus*.

Oellacher ('72) describes the filling of the egg of the trout and attributes it to the passage of water through the pore canals.

His ('73) in the salmon (Lachs) describes in the cortical layer certain bodies which he believes to be nuclei, but which are later described by

Henneguy ('88) as vacuoles filled with an albuminous fluid, and are therefore the cortical drops. He considered the perivitelline fluid to be water.

Kupffer ('77) describes the surface drops in the herring under the name of Dotterkoerner or yolk granules, as small, very refractive, glistening, homogeneous spherules forming a layer on the surface of the yolk. When the perivitelline space is formed these spherules disappear, and Kupffer says that he is unable to describe this disappearance otherwise than as solution.

At the same time that the perivitelline space forms the yolk contracts or grows smaller as Kupffer shows by measurements. From the fact that the yolk thus contracts, and from the fact that Reichert had previously obtained a precipitate in the perivitelline fluid by the use of nitric acid, Kupffer concludes that some part of the yolk substance is discharged into the perivitelline space. Most later writers (*e. g.*, Hoffmann) have taken this to mean that Kupffer believed that the surface drops dissolved. It is clear from what Kupffer says later that this is not what he has in mind. He describes a great increase in the hyaline portion of the yolk, and says that this increase takes place without any increase in the volume of the yolk. He believes that the yolk granules (cortical drops) are converted under action of the milt and water into this hyaline material, and it is this conversion that he cannot describe otherwise than as solution. Kupffer thus does not recognize any connection between the perivitelline fluid and the cortical drops, and offers no explanation of the filling of the egg. He believes that the composition of the perivitelline fluid is altered about the tenth hour by the dissolving in it of spermatozoa that have penetrated the egg membranes.

Kupffer refers to Boeck's statement that the eggs of the herring fill in 4% salt water without the addition of milt, but says that the eggs examined by him did not fill in fresh water or in .3% salt water, but did fill in .3% salt water upon the addition of milt. Kupffer is unable to explain this difference between his own experiment and Boeck's. The explanation may be as follows:—

The cortical drops are soluble in 4% salt water hence the egg fills in such water. They are not soluble in fresh water or in .3% salt water, hence the egg does not fill in these. By adding to the .3% salt water milt, the water is rendered alkaline, the drops are then soluble in it and the egg fills. The addition of milt to fresh water does not render it a solvent of the drops and hence the egg does not fill in it. It may be, as Kupffer suggests, that the water used by Boeck in his experiment actually contained milt. In either case it seems to me the explanation depends rather upon the solution of the surface drops than on the rendering permeable of a previously impervious membrane.

Ryder ('81) in the Spanish mackerel notes the existence of the cortical drops and their disappearance and considers them to be fluid-filled vacuoles. He notes them again ('81b) in Belone and thinks they may represent the disintegrated nucleus, but is inclined to doubt this from the fact that they do not stain.

Hoffmann ('82) mentions the cortical drops described by Kupffer in the herring and describes the perivitelline space in a number of other forms. He does not believe that the cortical drops dissolve but with the concentration of the protoplasm at the germinal pole they come to lie so close together that their borders fuse and they are no longer to be distinguished.

Ryder ('82) attributes the imbibition of water in the cod's egg to

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osmotic action. "The tendency of the membrane to assume the full or tense condition is doubtless due to capillary action of the pore canals." He notes the presence of cortical drops in the cod and describes them as running together and subsequently disappearing. He thinks they may be discharged into the perivitelline space but cannot prove this. He removed portions of the cortex and stained them and from the fact that the drops did not stain concluded that they were composed of some indifferent liquid, but not of oil since they were insoluble in alcohol or ether. Later ('83) he describes the perivitelline fluid of *Ameiurus albidus* as filled with numerous, free, highly refractive bodies which obscure the view of the embryo, but disappear in later stages.

Still later ('85) he describes cortical drops in the shad (*Clupea sapidissima*).

Owsiannikow ('85) notes the filling in *Osmerus* and seems to have seen surface drops in other forms.

Kowalewski ('86) describes the filling in two Teleosts and speaks of a thinning of the shell.

Solger ('86) found that the perivitelline fluid in *Leuciscus rutilus* behaved like yolk in rendering water turbid. By fixing it with osmic acid and examining it with the microscope he discovered in it numerous globular bodies which he believes to be identical with yolk elements. He regards these as normal and not accidental constituents of the perivitelline fluid, and notes that in later stages this fluid looses its power of rendering water turbid.

List ('87) notes the filling in *Crenilabrus* and is inclined to regard the perivitelline fluid as expelled from the yolk by its contraction. It is formed in both fertilized and unfertilized eggs.

Henneguy ('88) notes the filling of the egg and calls attention to the fact that Miescher proved the absorption of water by weighing the egg before and after the filling. Henneguy describes the bodies that were considered by His to be nuclei, as vacuoles filled with an albuminous substance. They are therefore the cortical drops.

Raffaele ('88) is known to me only from the abstracts in the Zoologische Jahresbericht and in the Journal of the Royal Microscopical Society and the references in the paper of McIntosh and Prince ('90). He studied a large number of pelagic ova and states that the perivitelline fluid is albuminous. He thinks that the food yolk formerly entirely filled the egg membrane and that it subsequently became reduced in quantity and gave rise to the perivitelline space, which has thus only a phylogenetic significance. It seems to me that there are numerous difficulties in the way of attributing to the perivitelline space any phylogenetic meaning. Beard ('90) has already given cogent reasons for believing the loss and gain of yolk food which has been postulated for the fishes by Rabl and others is, to say the least, not borne out by the facts of comparative anatomy and embryology. The arrangement of the fishes proposed by Beard is one not requiring any theory of a reduction in the food yolk of Teleosts. If this is true no morphologist would care to base the assumption of a loss of food yolk in Teleosts merely on the existence of a perivitelline space. Not only does the size of the space vary greatly among Teleosts, but its existence is by no means confined to that group. It occurs in Cyclostomes and Ganoids and Amphibia, and is a well known feature in many invertebrates (*e. g.*, *Lumbricus*, *Ascaris*). If it has phylogenetic significance in the one case why not in the others? It seems

to me that it is to be regarded rather as a contrivance for the protection of the egg and embryo, an adaptation that may have arisen independently in separate groups, and is wholly without phylogenetic meaning. As Ryder has pointed out it affords a medium like the amniotic fluid of vertebrates in which the embryo lives protected from mechanical injury by the tension of the egg shell which is produced through osmosis by the albuminous character of the medium.

Pouchet et Bietrix ('89). In *Alosa* (shad) describe the cortical drops and their disappearance under the action of water either with or without fertilization.

Agassiz and Whitman ('89) in *Ctenolabrus* describe the cortical drops as minute refractive spheres on the surface of the yolk. They render the yolk opaque but disappear with astonishing rapidity under the action of water and the egg is then transparent. In some instances the fertilized eggs cleared up within five seconds. They believe that the granules (cortical drops) swell a little and dissolve in situ. They do not believe that they are discharged into the perivitelline space as conjectured by Ryder.

McIntosh and Prince ('90) do not believe that much water gains access to the perivitelline space. They find that in stained sections "the fluid filling the space often appears coagulated and faintly stained, thus indicating the presence of minute protoplasmic particles. It would appear to be therefore a dilute plasma." They describe the cortical drops and their disappearance under the action of water, but regard the formation of the perivitelline space as due largely or wholly to the shrinkage of the yolk.

D.—CONCLUSIONS.

It appears from the foregoing review that the cortical drops have been many times described in a variety of Teleosts, and that their disappearance under the action of water has been often noted. The perivitelline fluid has been usually considered as water, though it was shown by Reichert to contain solids in solution and has been in recent years not infrequently regarded as albuminous. Unless some proof of its albuminous nature was given by Raffaele, the statement still rests on the observation of Reichert, which referred to the formation of a precipitate by means of nitric acid. No proof has been offered as to what becomes of the cortical drops when they disappear under the action of water, nor has any proof been offered of the cause of the filling of the egg or the function of the cortical drops.

The review of the literature shows that the phenomenon of filling and the presence of cortical drops and their disappearance under the action of water are universal facts among Teleosts, so that we may safely extend the explanation offered of the phenomena in the wall-eyed pike to all other Teleosts. We may say that in all Teleosts the cause of the filling of the egg is the albuminous cortical drops, that these drops dissolve in the first water which penetrates the egg shell (if the water is of the composition suited to the needs of the egg) and that there is thus produced a slight shrinkage of the egg body and at the same time a small perivitelline space filled with an albuminous fluid. This space then rapidly enlarges owing to osmotic action through the egg membranes. The egg membranes are thus stretched and rendered thinner and tense, so that they afford protection to the egg within.

It is most likely that the statements made with regard to the structure of the zona radiata in the wall-eyed pike apply equally to all Teleosts, but there is no means of determining this except by direct observation.

It is likely, too, that the account here given of the filling of the egg and the function of the cortical drops and the perivitelline fluid, is applicable to many invertebrate eggs. I will mention in support of this only the account given by Boveri ('87) of the contraction of the yolk and formation of the space in *Ascaris megalocephala*. Other instances are cited by Solger ('86).

PART III.

THE SPERMATOZOA.

A.—THE COMPOSITION OF THE MILT.

The milt of the wall-eyed pike is of the usual milk white color. It is scanty and viscous, so that when placed in water it does not mix with it, except by considerable agitation. It has a distinct and rather pronounced alkaline reaction. This reaction may be detected with ordinary litmus after the lapse of several hours in water which contains only enough milt to render it slightly turbid.

When examined under the microscope the milt (like that of all other Teleosts) is found to be made up of a large number of spermatozoa, moistened by a small quantity of a colorless fluid.*

The individual spermatozoa are so closely packed that they are in contact with one another and are nearly motionless. There is certainly nothing like progressive movement, although it is possible to detect a slight rolling movement of the heads, which may be physical.

Each spermatozoön (Fig. 17) consists, as is usual, of three portions, head (hd.), neck (nk.), and tail (tl.). The head is bean shaped about twice as long as broad and with a distinct notch on one side. It is difficult to measure it exactly in the living milt, but it is very nearly .0016 mm. long and, as stated, half as broad.

The neck is hemispherical and has a diameter not more than one-fourth the length of the head. It is less refractive than the head and is difficult to see. It is attached by its flat side to that side of the head on which the notch is, about half way between the middle of the head and the end. From the middle of the convex side of the neck projects the very delicate tail. The tail is as slender as it seems possible for a thread of protoplasm to be. Its length is many times that of the head, but is difficult to determine accurately. I have examined the spermatozoa of the whitefish and of the sucker, and have tried to verify on the whitefish the statements of Miescher ('80) with regard to the structure of the head of the spermatozoa of the Rhine salmon. I have not succeeded, although using the same methods as Miescher, in demonstrating any structure in the head of the spermatozoön. Whatever method of staining was employed, the head appeared always homogeneous.

Spermatozoa are single cells, as has been shown repeatedly by their

*Miescher found this fluid in the salmon to contain no albumen and principally inorganic salts. (Hermann, Handbuch der Physiologie.)

development. The head corresponds to the nucleus of an ordinary cell and the tail to a part of the cell protoplasm. The head may contain something more than the nucleus and the meaning of the neck piece is obscure. The extremely small size of the spermatozoön is to be explained as an adaptation to the work it has to do. The ovum is large and unwieldy by reason of the food material with which it is laden for the nourishment of the young fish. The ovum and spermatozoön must unite in order to produce a new fish, and since the ovum is incapable of movement, the spermatozoön must go to it. The spermatozoön therefore takes on the form that best adapts it for moving through the water. Its nucleus is reduced to a very small compass and becomes the head. To this head is attached only so much protoplasm, in the form of a vibrating tail, as is necessary to move the head.

B.—BEHAVIOUR OF SPERMATOZOA IN WATER.

It has been said that in the milt as it leaves the fish the spermatozoa are nearly or quite motionless. The moment the milt comes into contact with water, they exhibit the liveliest movements. In order to observe the movements and the length of time during which they last the following procedure may be resorted to. The body of the fish should be first wiped with a towel more particularly about the vent, so as to remove as much as possible of the water and slime and prevent its becoming mixed with the milt. The milt should then be stripped from the fish into a small glass dish (solid watch glass) with a close fitting cover or into a homeopathic vial which should be afterwards tightly corked. The milt should be carefully protected from contact with water but, if it is desired to keep it alive for a long time, the vessel containing it should be set into a dish of cold water or onto a block of ice. A slide and cover glass should be made ready and a drop of water placed on the slide. Then with any small instrument such as the end of a glass rod or the point of a tooth pick remove a very small quantity of the milt from the bottle and mix it as rapidly as possible with the water by stirring it about, and at the same time make note of the time when the milt first touched the water. Apply the cover glass and place the preparation under the microscope as quickly as possible.

The spermatozoa will now be found undergoing the most vigorous movements. They dart here and there with such rapidity that it is at first hard to follow them. At first only the heads can be seen, the tails are moving so rapidly that they are invisible. The movements soon become slower and then one can see that they are caused by the tails which are moving back and forth in a sinuous course not unlike the movements of the body of a water snake when it is swimming. At the end of forty-five seconds nearly all the spermatozoa have become motionless, only here and there may be seen an oscillating head or a moving tail, while occasionally a spermatazoön moves rapidly across the field of the microscope and stops. At the end of a minute all signs of life have usually disappeared and the spermatozoa lie as if dead.

I did not detect and indeed did not look for any difference in these spermatozoa before and after the action of the water on them. In examining the spermatozoa of one of the suckers common in Saginaw Bay in May, the water was found to produce such striking changes that they could not fail to attract attention. Like spermatozoa of the wall-eyed pike those of the sucker become motionless after a stay of a few seconds

in water (the exact time was not determined). As they come from the fish the very large heads of these spermatozoa have the form of a short rod with rounded ends. They are almost egg-shaped but rather more slender than an egg. They have the dense appearance and refractive properties common to the heads of spermatozoa. When they have been a short time in water the heads begin to swell and become paler. They become at first egg-shaped and finally almost globular, and the spermatozoa become at the same time motionless. If one places a drop of the milt on a slide and covers it so that the drop lies at the center of the cover glass and then adds water about the edge of the cover, one may watch the gradual penetration of the water into the milt and see its effect on the spermatozoa. One then has in the same field spermatozoa in all stages of water imbibition and may compare them. As the water reaches a spermatazoön it is seen to start up more vigorously for a few seconds, gradually swell up and then subside. It would be interesting to know whether the spermatozoa thus swollen by the action of the water are capable of entering the micropyle of the egg. If the spermatozoa of the sucker are of such a size as to be only just able to enter the micropyle before water has acted upon them, they would be wholly unable to do so afterward and it is possible that the swelling prevents the entrance into the egg of more than a single spermatozoön. By the time the first spermatozoön had made its way into the micropyle the others would probably be so much enlarged that they would be unable to pass through the micropylar canal, even although still in motion.

The spermatozoa of the wall-eyed pike are thus motionless af the end of three quarters of a minute to one minute, but are they then dead? Probably the best test that can be made of this question is to attempt to fertilize eggs with milt that has been mixed for a certain length of time with water. In order to test this four lots of eggs of the wall-eyed pike, each containing twenty-five eggs were fertilized as follows:

To lot 1 was added milt that had been 10 seconds in water.
2 " " " " " " 30 " " "
3 " " " " " " 60 " " "
4 " " " " " " 120 " " "

At the end of four hours the eggs were segmenting and were then counted to determine how many in each lot had been fertilized. The result was as follows:

	Fertilized.	Not fertilized.	Injured.	Per cent of uninjured eggs unfertilized.
Lot 1	13	4	8	24
Lot 2	13	5	7	28
Lot 3	15	7	3	32
Lot 4	0	19	6	100

The eggs were arranged for the experiment in rows in a watch glass, as already described. In order to do this it was necessary to handle each egg separately, which accounts for the considerable number of injured eggs. The table shows a steady increase in the percentage of unfertilized eggs, as the length of time increases during which the spermatozoa have

been subjected to the action of the water. Omitting the injured eggs, which cannot be counted in the experiment, the fourth column shows the percentage of uninjured eggs that were unfertilized. There is little difference between ten seconds and thirty seconds, but at one minute the effect of the water is already noticeable, and at two minutes not a single egg is fertilized. Other experiments of the same sort gave similar results, and the conclusion that the effect of the water is not merely to render the spermatozoa motionless, but to render them incapable of fertilization.

The milt of the whitefish was also studied and found to be killed by the action of water. The time here was found to be two minutes. The eggs of the whitefish develop so slowly that it was not found practicable to repeat the experiment in fertilization that had been made with the wall-eyed pike. It is possible to criticise this and similar experiments by saying that the fact that the spermatozoa that have lain in water are incapable of fertilizing eggs does not prove that they are dead. It may be that their condition of immobility prevents their entering the micropyle, whereas if they could be brought into contact with the egg they might still be capable of fertilizing it. It may be said that the spermatozoa are rendered motionless, but not necessarily dead, in order to prevent more than one of them from entering the egg. An attempt was therefore made to determine by means of the methylen blue reaction whether the motionless spermatozoa were really dead. Living spermatozoa were treated with solutions of methylen blue .001 to .0001 in .75% salt solution. In this stain the spermatozoa live and move for a time varying between ten seconds and two and a half minutes. They do not stain at all or only very slightly so long as they are in motion, but become deeply stained the moment they are dead. It is known that this stain does not ordinarily affect living nuclei, but that it stains deeply dead nuclei, so that the fact that the heads of spermatozoa stain instantly in methylen blue may be taken as evidence that the spermatozoa are dead. If they stain very slowly they are probably living, though possibly not in motion. A comparison was then made between the rapidity of staining in methylen blue of spermatozoa that had ceased to move on account of the action of water and of those that had been killed by the use of heat, or osmic acid or by other means. No difference could be made out between spermatozoa that were known to be dead and those that were motionless from the action of water and it was concluded that the water kills the spermatozoa.

Although the spermatozoa of the wall-eyed pike and of the whitefish thus die rapidly in water, they nevertheless live for a considerable time in some other fluids. In salt solution of .75% the spermatozoa of the whitefish may live for twenty-two minutes or longer, while those of the wall-eyed pike remain active for about a half hour, and individual spermatozoa may sometimes be seen moving at the end of an hour. This strength of salt solution is the one employed by histologists when they wish to keep tissues alive for a long time and is made in imitation of the natural fluid of the body, so that it is not surprising that the spermatozoa should live in it.

The fluid which bathes the eggs when they are laid is one in which the spermatozoa live well. Spermatozoa of the wall-eyed pike mixed with this fluid were found to be still in motion after one hour and thirty-five minutes. When the cover glass was raised and water added to the preparation, vigorous movements were set up and lasted for forty-five seconds. These movements were almost as vigorous as those obtained by mixing the

milt directly with water, but were not quite so general. This fact is one that may be of some importance in practical fish culture.

In attempting to determine under the microscope the length of time during which spermatozoa continue to move in the water, care must be taken not to confound the vital movements of the spermatozoa with the Brownian movement. This error, as pointed out by Quatrefages, was made by the older observers before the Brownian movement was known. It is now well known that minute particles of any solid suspended in water undergo constant trembling movements which are visible under the microscope. This may be seen by rubbing up carmine, fat or lampblack in water. This movement is wholly physical and is exhibited by the heads of dead spermatozoa.

C.—HISTORICAL AND CRITICAL ACCOUNT OF THE VITALITY OF FISH SPERMATOZOA.

The facts just recorded that spermatozoa become speedily motionless in water and that such motionless spermatozoa are not then capable of fertilizing eggs, were known to observers in the middle of the present century.

They are therefore not presented here as new facts, but for the reason, as it seems to me, that they have not been sufficiently brought to the notice of fish culturists in this country. The limit of life of the spermatozoa of the two species that are most largely handled in our fresh waters has not, so far as I know, been previously determined, and its extreme shortness needs to be thoroughly realized.

Although it was known that the spermatozoa of fresh water fishes become motionless in water and are then incapable of fertilizing the eggs, no careful work was done on the subject until 1853, when Quatrefages was led to investigate it in the interest of fish culture.

Costé ('59) states that he had found it impossible to fertilize the eggs of the trout with milt that had been eight minutes in water, and he further states that the spermatozoa of the perch and carp and of *Cyprinus* and *Leuciscus* live only two or three minutes in water. These facts are recorded, but it does not appear whether those relating to the perch, carp, *Leuciscus* and *Cyprinus* are the results of the work of Quatrefages or not. The time of eight minutes obtained on the trout is undoubtedly eight times too large and probably resulted from an imperfect mixture of the milt with the water.

Quatrefages ('53) was the first person to determine accurately the the length of life in water of the spermatozoa of fresh water fishes. The results of his work were of the greatest importance and have not been since materially modified, so that I here give a somewhat full resumé of them.

The experiments were made on the milt of the pike (*Esox*) *Leuciscus*, the carp, the perch and *Cyprinus* and gave the following times at the end of which the spermatozoa were all dead in water in the milt of the species named.

Pike, 8 m., 10 sec.
Leuciscus, 3 m., 10 sec.
Carp, 3 m., 10 sec.
Perch, 2 m., 40 sec.
Cyprinus, 2 m., 10 sec.

The time given is the longest time during which any spermatozoön was found to be living. Half the spermatozoa of the pike were dead at the

end of 2 m, 2 sec., and at the end of 2 m. in Leuciscus. In the carp two-thirds were dead at the end of 2 m. In the perch and in Cyprinus 1 m. was sufficient for half the spermatozoa to become motionless.

The time given is only accurate where the milt is mixed thoroughly with the water so that the water has free access to each spermatozoön. If the milt is placed in water and allowed to remain in masses of any size, spermatozoa may remain alive in the center of these masses for a long time and the milt may thus serve for fertilizing eggs eight minutes after being placed in water, as found by Costé, or even longer.

Quatrefages found further that the temperature of the water used had an important influence on the length of life of the spermatozoa. There was a certain temperature at which the spermatozoa of each species remained in motion longest. Thus for the pike, the spermatozoa were motionless at

2° after 8 m., 10 sec.
2.8° after 5 m.
10.5° after 4 m., 55 sec.
22° after 1 m., 20 sec.
28° after 3 m., 20 sec.
38° almost instantly.

For the carp at

12° after 3 m.
18° after 2 m., 30 sec.
25° after 2 m., 20 sec.
40° after 20 sec.
65° instantaneously.

At lower temperatures in the carp the following results were obtained:

9.50° in 10 sec. 4-5 of the spermatozoa were motionless.
8° in 10 sec 19-20 of the spermatozoa were motionless.
2° in 10 sec. nearly all the spermatozoa were motionless.
0° there was no movement.

The other species gave similar results, showing that a certain temperature is necessary for each species and that any considerable departure from this temperature shortens the life of the spermatozoa. The temperature is moreover very different for different species, so that water in which the spermatozoa of the pike live longest renders the spermatozoa of the carp almost instantly motionless.

Quatrefages found that the milt of fish might be kept in good condition and capable of fertilizing ova, if preserved from contact with water. Thus milt taken in the evening from a pike killed in the morning contained very active spermatozoa. He found, moreover, that the spermatozoa still in the tests preserved their vitality for twenty-four to thirty-six hours longer than those in the milt. The spermatozoa retained their vitality in the dead fish longer if the fish was kept at a low temperature, and the best results were obtained when the tests were removed from the fish and placed on ice. They may be even frozen into a block of ice without apparently suffering any loss of vitality. Quatrefages then draws the following conclusions from his observations.

1. "From a large number of experiments which I am unable even to mention it results that with certain fish, a variation of four or five degrees above or below a fixed temperature is sufficient to shorten by more than half the life, already so short, of the spermatozoa. We can understand therefore, how the period of spawning in these species may vary notably

from one locality to another, contrary to what is observed not only among warm blooded animals, but also among the greater number of cold blooded animals. We can understand also how the spawning may be hastened, retarded, or even suspended during several days, to recommence afterwards, as I have been able to determine this very year for the perch and Leuciscus. In these species the acts related to reproduction are immediately dependent on certain climatological phenomena."

2. "The extreme shortness of the life of the spermatozoa and the influence which the temperature exerts upon them are certainly to be numbered among the causes which most efficiently hinder the crossing of species and the production of hybrids among fishes. Impelled by instinct the males deposite their milt almost in contact with the eggs laid by their females and the spermatozoa have not time to travel even to very short distances to fecundate other eggs than those to which they are destined."

3. "We have seen that the maximum of vitality presented by the spermatozoa of the pike is more than double the maxima found in the carp and perch, and about four times as great as the maxima of the spermatozoa of Cyprinus. The latter spawing at very variable temperatures, and being able consequently to encroach upon the time of spawning of a certain number of species, a very short existence of its spermatozoa was therefore the more necessary as a guarantee against possible crossing. Among carp and perch which spawn in bands and assemble sometimes to the number of several thousands upon a single spawning ground, fecundation is always almost assured by the very fact of this assembling and the short duration of the life of the spermatozoa would present only advantages without having any inconvenience. It could not have been the same with the pike, which, like all fierce animals live in isolation, and spawn, so to speak, as M. Millet assures me, in pairs. It is necessary here that the milt ejaculated by a single male, and always in small quantity, should have time to act upon the eggs and this end is attained by much greater persistence of the vitality of the spermatozoa."

4. * * * * * * * *

5. "It has been heretofore quite difficult to find a reason for the instinct which urges certain fish, the trout and the salmon for instance, to ascend rivers, to sometimes enter trenches where they find scarcely the amount of water necessary for their movements, and also to explain the preference for certain water courses or for certain points on the same river. Usually it has not been possible to cite as a cause the chemical composition of the waters. In regions entirely granitic or schistose, this composition could scarcely vary for the sources coming from the same mountain, and in any case it should remain the same for the same water course examined at certain distances.

"Fishermen, however, know very well the bottom that serves every year for the spawning of the fish. They know equally well that some neighboring bottom placed apparently in identical conditions never receives the visit of spawning fish. All these facts are readily explained by the influence of temperature. If winter fish ascend the rivers and stop at a certain distance from their sources, it is to find a water the temperature of which shall be exactly that which the fecundation and development of the eggs renders necessary. At the mouth the temperature would be too high, at a distance perhaps more remote the liquid would be too cold. It is between these two points that the fish of which we speak must find a suitable degree (of temperature) and they ascend until they have encountered it."

Kölliker ('55) confirmed the observations of Quatrefages as to the injurious effects of water, and called attention to the fact previously noted by Dujardin that the heads of the spermatozoa swell in water.

Other writers seem to have given only incidental attention to the spermatozoa of Teleosts until we come to *Henneguy* ('77). He repeated the experiments of Quatrefages and found that the spermatozoa of the trout continued in motion for thirty seconds. The temperature is not stated. The time, it will be noted, is only one-sixteenth that given by Costé, but might have been longer at a different temperature. Henneguy tested the power of the milt to fertilize eggs and found that not a single egg could be fertilized with milt that had been for one minute in contact with water.

After fifteen seconds in water the movements of all spermatozoa are slowed while some are motionless. Out of sixty eggs fertilized with this milt forty-six hatched. He kept milt for four days in a flask at 10.15° C. and at the end of the time found the movements of the spermatozoa when mixed with water, normal. Forty eggs were fertilized with this milt and thirty-two hatched. Henneguy and Kölliker tried other experiments by mixing various drugs with the water containing the spermatozoa but these do not concern us here.

The observations above recorded of Costé, Quatrefages and Kölliker and Henneguy all refer to species of fish spawning in fresh water.

On the other hand the observations of Ransom ('66, p. 460) on the stickleback (Gasterosteus leiurus) indicate a much longer life of the spermatozoa in fresh water. In one place he speaks of the spermatozoa as moving at the end of seventeen minutes but motionless at twenty minutes and in another place says "The spermatozoa were seen actively moving during the twenty-five minutes I watched." In view of the uniform results obtained by observers who have given attention particularly to this point these isolated observations of Ransom require confirmation. He worked with a power of only one hundred diameters and may have mistaken other movements for vital ones.

Kupffer ('77) describes moving spermatozoa *in the perivitelline space* nine hours after fertilization.

I have found no observations particularly directed toward this point in those species that spawn in salt water. Casual references to the subject by observers working at other points are likely to be of little value owing to the liability to the error of confusing the Brownian or other physical movement with vital movements. Only those observations should be accepted that show that the spermatozoa called living are capable of fertilizing the eggs, and I know of no observations of this sort on species spawning in salt water.

Hoffmann ('82) speaks of the spermatozoa of Scorpaena as dying very quickly in sea water and as not showing movements after thirty minutes.

Hensen ('83) says that the milt of the cod placed in water having a saltiness of 1.9% immediately showed very lively motions lasting as long as one and one-half hours, and adds: "I have certainly seen a spermatozoön (in the micropyle of an egg which had probably been impregnated) in motion for that length of time."

It is certainly true that the spermatozoa of all Teleosts observed live but a short time in fresh water. The explanation offered by Quatrefages is very likely the true one. The death of the spermatozoön is a contrivance, probably only one of several, for preventing hybrid fertilization. That it is possible to fertilize the eggs of one species of fish with the milt of another and thus obtain hybrids has been proved by numerous trials

I need only mention here the case cited by Ryder ('85, p. 503) of "specimens in my possession of young striped bass hatched from ova fertilized with the milt of the white perch (Roccus Americanus)." And the further remarkable case cited in the same place of a hybrid between the shad and the white bass, two widely separated forms.

If then the spermatozoa of fish were capable of living for even a few hours in water and of moving about, an opportunity would be afforded for their coming upon eggs of other species and fertilizing them. If on the other hand the spermatozoa die in water within one or two minutes, it would practically never happen that they would reach eggs other than those for which they were intended.

Wherever the act of spawning has been observed among fish it has been found that the male and female go together and that the spawn and milt are either ejected into the water at the same time or the milt is ejected over the spawn immediately after it is laid.

Von Baer ('35) gives an account of the spawning of Cyprinus blicca. "The fish go in herds and each spawner is surrounded by a number of milters. They strike violently against one another and at the same time turn their bellies toward one another. This is probably the time when a part of the spawn escapes. Often one sees a male so eager in the pursuit of a female that when she is closely surrounded by other males, he rushes over all of them and is raised up with half his body out of the water." Von Baer also quotes *Argillander* as giving an account of the spawning of the pike and *W. Grant* as giving an account of the spawning of the salmon. In both cases the male and female fish are described as lying close together in a previously prepared nest and going through movements calculated to bring their bellies together and to expel the eggs.

Rusconi ('36, b.) gives an account of the spawning of Cyprinus gobio, in which the fish are described as passing for two or three feet up the mouth of a brook, males and females together and lying on the bottom with their backs out of the water. In this position they curved their bodies and swept their tails back and forth, and remained thus seven or eight seconds. At the end of this time each gave the bottom a violent blow with the tail so that the water spurted out on all sides and then turned and returned to the lake. Examining the place Rusconi found spawn. He did not observe that the fish paired but only that males and females were together.

Vogt ('42, p. 16) says of the European whitefish (Coregonus paleae) "It is known that the paleé always spawn in pairs and that they announce their presence to the fishermen by leaping above the surface of the water one against another. It is at this moment that fecundation is effected by the simultaneous ejaculation of eggs and milt.

Costé ('59) gives an account of the nesting habits of the stickle-backs and relates how the male when he has prepared the nest leads the female to it. When she has deposited her eggs the male follows immediately and ejects the milt upon them. Should the female be slow in leaving the nest, he drives her out in order to get access to the eggs.

Milner ('73) gives an account of the spawning of whitefish in the Detroit river as follows: "Driven by the persistent attention of the male the female rose vertically, he following and she making a convulsive effort to escape, the water being from three to ten feet deep, they threw themselves together above the surface, and the spawn and milt were emitted at the time when from their position their vents were approximated."

From these accounts, and I have no doubt the literature contains many more, it is clear that the bringing together of the ova and spermatozoa of Teleosts is by no means a matter of chance in fresh water. The fact that the eggs are laid in the presence of the male (and probably only then) insures their speedy contact with the spermatozoa. The short life of the spermatozoa guards against the chance of their wandering away to come into contact with other eggs. In short, instead of the fertilization being a matter of chance, there seems to be abundant contrivances to insure that it shall not be a matter of chance. In the eggs of fish spawning in salt water it may be different.

Ljungman ('78) describes the herring spawning thus: "During the spawning process the herrings are packed in a dense mass are in constant and violent motion, move their tails rapidly, press and rub against the nets, etc., all with the obvious intention to facilitate the emptying of the sexual organs. It has been observed that during the emission of the milt the sea water assumes a whitish color and a peculiar odor becomes perceptible."

Earl ('78) thinks the ova of the cod may be fertilized largely by chance, since he has not observed the fish going in pairs.

The statements of Hensen and Hoffman with regard to the length of life of the spermatozoa make a chance fertilization possible in salt water. On the other hand neither Hensen nor Hoffman showed that the spermatozoa described by them as moving were capable of fertilizing eggs and the account of Ljungman indicate immediate fertilization in the herring.

The evidence is therefore not sufficient to decide the matter in salt water spawners, and it remains to be said that even should it prove true that in some such forms fertilization may take place by chance and the spermatozoa be endowed with a considerable length of life, yet this does not invalidate the conclusion with regard to spawners in fresh water. While the short life of the spermatozoön in those fish that spawn in fresh water may serve to prevent the formation of hybrids, the same result may be attained in salt water spawners in a different way and a long life of the spermatozoön may serve a useful purpose.

Thus in the case of the herring, the immense number of fish congregated on the spawning ground would tend to drive away all other fish and prevent hybrid fertilization in that way. In the method of spawning observed in these fish it would be of advantage that the water should be kept filled with actively moving spermatozoa, and this could be better accomplished if the spermatozoa were endowed with considerable length of life.

PART IV.

THE FERTILIZATION OF THE EGG.

A.—THE LIVING EGG.

In order to study the process of fertilization it is convenient to arrange the eggs in rows in a watch glass in the manner described for studying the changes produced by water in the unfertilized egg. A second watch glass containing water is placed at hand and a small quantity of freshly expressed milt is then taken up in a pipette and

mixed with the water in the watch glass as quickly as possible by drawing the water into the pipette and forcing it out again several times in rapid succession. The milt thus diluted is placed on the eggs with the pipette and reaches them in between five and ten seconds after it has been mixed with the water. The milt is allowed to remain on the eggs for ten or fifteen seconds and is then removed by changing the water several times rapidly. All this can be accomplished without changing the position of the eggs since the water causes them to adhere firmly to the watch glass.

The eggs, after washing, are brought under the microscope and are under observation within thirty seconds of the time the milt is mixed with the water. This method is a slight modification of the one used by Calberla in studying the eggs of the lamprey eel.

One runs rapidly along each row of eggs until an egg is found which presents the micropyle in profile, *i. e.*, in such a position that one sees the micropyle at the edge of the egg, and can a little later see the micropylar funnel and canal from the side throughout their whole length. It requires some practice to pick out quickly an egg in the right position for observation.

By the time this is accomplished the movements of the spermatozoa will usually have nearly ceased, but one may see here and there a feeble movement. It is now noticed that each egg is thickly covered with spermatozoa, the heads of which appear under the power that can be used as minute granules thickly studded over the external egg membrane (Fig. 23 spr.). They are not usually in contact with the external egg membrane nor are they held firmly by it, since a little gentle washing suffices to remove them, while the external egg membrane is plainly seen within the zone formed by the spermatozoa about the egg. The spermatozoa are held in place by the fluid which covers the eggs when they are laid and a film of which remains on the surface of each egg when they are arranged in the watch glass. The water gradually dilutes and washes away this fluid, and as this happens the spermatozoa are freed and may be seen floating away. This fluid thus affords to the egg a means of attaching to itself spermatozoa on all sides, as long ago noted by Costé ('59), and may thus serve a useful purpose in rendering the fertilization of the egg more certain.

It has been pointed out that the spermatozoa live much longer in this fluid than in pure water, and it might be expected that those spermatozoa held in contact with the egg by this fluid would continue their movements longer than those in the adjacent water. The experiment was therefore tried (and many times repeated) of first placing the eggs under the microscope and then adding the milt. In doing this it is necessary to have the milt very dilute in order that it may not render the water so milky as to obscure the view of the egg. Eggs thus treated were watched to see whether the spermatozoa in contact with the egg lived longer than those in the adjacent water. It was found that in every case their movements were arrested at the same time with those in the water. There is no evidence that contact with this fluid prolongs the life of a spermatozoön that has once come into contact with water. Probably a very short contact with water leads to the death of the spermatozoön, even although it is, as in this case, immediately afterwards removed from the water.

The layer of spermatozoa that covers the egg may be uniformly distributed over its surface or it may be thicker on one side than on the other. In a number of cases it was noticed that the layer was much thicker

over the germinal disc than elsewhere, and it was thought for a time that the germinal disc might exercise through the shell some influence on the spermatozoa that should bring them in greater numbers to that side of the egg. An examination of a large number of eggs with this point in mind showed, however, that it was merely a matter of chance as to where the greatest accumulation of spermatozoa occurred. It was as likely to be on the side opposite the germinal disc as on the side of the disc.

There is one possible exception to this statement. In many cases it was noticed that there was an accumulation of spermatozoa directly over the micropyle. The appearance presented was as though a large number of spermatozoa had rushed toward the micropylar funnel. Such accumulations were conical or sugar loaf shaped and sometimes of a height equal to the thickness of the shell. These accumulations did not always occur, but occurred so frequently as to make it improbable that they were due to chance. It is likely that they are formed either by the crowding together of spermatozoa in their efforts to enter the micropyle or by the presence over the micropyle of a projecting plug of some material in which the spermatozoa become entangled. If such a plug of material exists it is too delicate to be detected by the methods used though it is possible that a suitable staining method would reveal its presence.

Within two minutes after the egg comes under observation the cortical drops will usually have disappeared, and one may then see the beginning of the perivitelline space (Fig. 11, pv.). It sometimes happens that this space appears about the whole circumference of the egg at the same time, but it is more frequently the case that it appears over every other part of the egg except at the mycropyle, so that while the zona radiata is separated from the cortex over its whole inner surface it still remains in contact with it at the micropyle (Fig. 11.). In such cases the micropylar elevation is seen to be imbedded in the germinal disc. I am inclined to believe that it is always the case that the last point of contact between the zona radiata and the cortex is at the micropyle, but that sometimes the changes are gone through with so rapidly that this fact escapes observation. The rapidity with which the phenomena now to be described follow one another depends upon the temperature. The most complete record which I have preserved is one made at a comparatively high temperature but unfortunately my notes contain no record of the temperature at this time.

Two and a half minutes after adding milt the perivitelline space was found (in the case recorded) but the micropylar elevation was still in contact with the germinal disc. At three minutes and twenty-five seconds the micropylar elevation is entirely withdrawn from the germinal disc and the disc itself is already somewhat thickened. There now appears on the point of the disc with which the micropyle was in contact a clear elevation of the protoplasm (Figs. 11a, 23, 24, 26, 27, i., em.), which has the form of a nipple and bears at its end a slight crater-like depression. This elevation I shall call the impregnation eminence. If one watches very closely the separation of the micropylar elevation from the germinal disc one may often see the impregnation eminence make its appearance an instant after the separation and at the very point on the disc which was in contact with the micropylar elevation (Fig. 23). In other cases the impregnation eminence is not seen until some little time after the micropyle has separated from the disc and it then lies at one side of the microple (Figs. 26 and 27). In either case it may be seen first as a very slight projection (Fig. 23, d.) which gradually becomes higher (Fig. 23,

c. and b.,) and finally takes on the form of a nipple with the crater-like depression already described (Fig. 23, a). When fully formed it has a breadth of about .020 mm. and is about half as high. The eminence is therefore so slight that it is easily overlooked and in order to be seen it is necessary that it should lie at what appears to be the very edge of the disc as one looks at it from above. Of course not all eggs placed by chance lie in this position, so that it is necessary to pass rapidly from egg to egg until a suitable one is found. If one finds an egg in which the micropyle is presented in profile as in Figs. 10 and 11, the impregnation eminence is almost certain to show. After having examined many hundreds of eggs and seen the eminence perhaps a hundred times I have no hesitation in saying that it always occurs and that if it is not visible this is owing to the position of the egg. One who has become thoroughly familiar with it may often overlook it at first, but afterwards see it lying a little above or below the median optic section.

The eminence is usually borne on the top of a rounded elevation of the germinal disc of about the form of an inverted saucer (Fig. 27 and Fig. 11a.). This second elevation is about ten times as broad as the impregnation eminence and about three times as high, and is composed of protoplasm slightly less granular than that of the rest of the disc, but much more granular than that of the impregnation eminence. I shall speak of it as the granular eminence. It varies somewhat in its proportions and does not always appear to be present (Figs. 23 and 26), at least I have often failed to see it, although it may have disappeared before my observation was begun. It may be said with certainty that if it is always present, it does not persist during the whole time during which the impregnation eminence is present.

The impregnation eminence persists for a time varying between two and five minutes and is then withdrawn. One side of it is often withdrawn first and then the other, the whole process of withdrawal lasting one or two seconds and being much more rapid than the appearance of the eminence. In one case the impregnation eminence was seen at the end of thirteen minutes after fertilization, in an egg at a temperature of 9° C., but in most observations which were made at a higher temperature (probably 11 or 12° C), it had disappeared at the end of five or six minutes. The granular eminence disappears at the same time as the impregnation eminence.

I have in one case observed two impregnation eminences near one another on the same disc. They were not borne on granular eminences and were smaller than normal. In another case I observed a considerable number, perhaps a dozen, slight conical elevations of the germinal disc scattered irregularly over its surface and each much smaller than an impregnation eminence and without a crater-like depression at its apex. In this egg I did not find the usual impregnation eminence. Aside from these two cases I have seen always a single impregnation eminence in each egg, and I have seen it always arise and disappear in the same way and about the same rate and nearly always borne at the top of a granular eminence.

The fact that the impregnation eminence appears at that point of the disc which was in contact with the micropylar elevation, suggests at once that it is caused by the contact of the spermatozoön with the egg. Many unfertilized eggs were examined to see whether the impregnation eminence could be found in them, but always with a negative result. I was never

able to find in an unfertilized egg anything in any way resembling an impregnation eminence, although in other respects the unfertilized egg behaves precisely as does the fertilized egg during the interval between laying and the time of appearance of the first segmentation furrow.

It is therefore rendered certain that the impregnation eminence is due to the contact of the spermatozoön. The spermatozoa are so small and the egg so opaque during the first minute of its contact with water, that nothing could be made out as to the passage of the spermatozoa through the micropyle. The considerable size of these eggs makes it impossible to use a very high power and they are therefore not as favorable for these observations as many pelagic eggs.

Careful observation was made of the impregnation eminence to see whether a spermatozoön could be found attached to it or whether spermatozoa could be seen moving about near it in the perivitelline space. In no case was anything found attached to the eminence that could without doubt be considered a spermatozoön. In one case a small granule of the size of the head of a spermatozoön was seen attached to the eminence at one side of the crater and the eminence was immediately withdrawn. In other cases similar granules were seen moving very near the eminence, which was immediately thereafter withdrawn. Without further data one would have no hesitation in calling these granules the heads of spermatozoa, and in believing that the contact of the spermatozoön with the impregnation eminence and the *consequent* withdrawal of the latter had been actually observed. The movements of the granules are precisely like those of slowly moving spermatozoa heads, and it is easy to imagine, as I have done, that one sees the moving tail of the spermatozoön. When the granules are moving somewhat rapidly and slowing or stopping frequently, the impression left on the retina by the path of a granule may be so combined with the image of the granule as to give rise to the impression of a very properly constructed spermatozoön. This is particularly true if one has actual spermatozoa in focus in the same field on the outside of the zona. An examination of unfertilized eggs that have been placed in water without any contact with spermatozoa shows, as already described, the same granules behaving in the same way, and the possibility of their being spermatozoa heads is thus at once excluded.

After the disappearance of the impregnation eminence, the behavior of the unfertilized and fertilized eggs as seen in the living egg is identical. The perivitelline space continues to increase in size and the germinal disc to accumulate in both at the same rate. There is one series of phenomena which takes place in both fertilized and unfertilized eggs, but which is so intimately associated with fertilization that it will be described in this connection. I refer to the formation of the *polar bodies*, and repeat that so far as can be made out in the living egg, this process is absolutely the same in the unfertilized egg that it is in the fertilized and proceeds at the same rate.

Polar bodies are believed to be formed in all animals before fertilization can be completed, and before, therefore, any development of an embryo can take place. The process of the formation of the polar bodies is usually spoken of as the maturation (ripening) of the egg.

There are two polar bodies formed in the wall-eyed pike as in other animals. The first one may be seen in the living egg between thirty and forty-five minutes after fertilization. It appears at first as a small, perfectly transparent hemispherical elevation of the germinal disc (Fig. 13). The elevation is colorless and free from granules, and has a distinct dark

border indicating the presence of a well defined membrane. The elevation is about .012 mm. in breadth (about one-half the breadth of the impregnation eminence). It becomes gradually higher, and in the course of from six to ten minutes is nearly as high as broad, and a notch has appeared on either side of it. The appearance in the living egg is as though it were first raised up above the surface of the germinal disc and then pinched off by a constriction running entirely about its base between it and the disc, so as to separate it from the disc. It will be seen from an examination of sections that this appearance does not quite represent the facts. When the first polar body has thus been separated from the germinal disc it is a perfectly transparent and colorless sphere (Figs. 28, 29, 33, p. b. 1.). As soon as the first polar body is raised up from the surface of the disc enough so that one can get a view of that border of it which lies next the disc, one sees that it is borne on the top of a second elevation, the *second polar body* (Figs. 28, 29, 33, p. b. 2). The second polar body is clearly seen about twenty minutes, or twenty-five, after the appearance of the first. In the course of ten or twelve minutes it has extended above the level of the disc to about half the height of the first polar body, which it bears on its apex. In twenty minutes after the first appearance the second polar body has reached a height equal to that of the first (Fig. 29) and in thirty minutes it has separated entirely from the germinal disc (Fig. 33).

The second polar body is then seen to be different from the first in a number of particulars. It is somewhat larger and is less regular in outline. It commonly appears in a side view to be of a truncated triangular form with the first polar body borne on the truncated apex of the traingle, but it may have other forms. It nearly always has one side flattened against the germinal disc. It is, moreover, not clear, like the first polar body, but granular. It appears to be made up of a considerable number (12 to 24) small separate granules loosely held together (Fig. 33). It consequently appears darker and less sharply defined than the first polar body, so that it is more difficult to see.

When the polar bodies are fully formed they lie side by side on the surface of the disc. They probably eventually break up in the perivitelline fluid, but I have not attempted to follow this process. I have seen the polar bodies after the formation of the first segmentation furrow attached to one of the segments near the furrow.

The point on the disc at which they appear is always (as noted by Agassiz and Whitman) at one side of the middle of the disc (Figs. 13, 14, 28).

I have examined a large number of specimens for the purpose of determining this point. In fourteen cases thus examined in one lot of *fertilized* eggs, the polar bodies were plainly eccentric in thirteen, while in the remaining egg they appeared to be central. It is of course possible that they were actually eccentric in the fourteenth egg, since in this case the optical section may not have passed through the middle of the disc. In fourteen unfertilized eggs examined at the same time, the polar bodies were decidedly eccentric in ten and appeared to be central in four. One who wishes to understand the conditions under which these determinations were made, may take a watch glass or other similarly shaped dish and make an ink spot a little to one side of the center of the convex side of the dish. If he then looks at the edge of the dish, the dish will represent the germinal disc of the egg and the spot will indicate the position of an eccentric polar body. By turning the dish about while still looking at its edge he will see that the polar bodies may *appear* to be central while

they are actually eccentric. If he then makes a spot in the center of the dish, he will see that however he turns the dish the spot appears to be always central. While an eccentric polar body may appear to be central, a central polar body can never appear to be eccentric. We may therefore conclude that in the wall-eyed pike the polar bodies are eccentric in position in both fertilized and unfertilized eggs.

It was shown above that the germinal disc about ten minutes after the egg comes into contact with water has the form of a saucer with its concave side fitted against the yolk. This form, as was stated, it retains for more than an hour, that is during the whole time during which the polar bodies are being formed (Fig. 13). Shortly after the formation of the second polar body the disc again begins to change shape becoming thicker and higher (Fig. 14) as already described, until it finally has the form of a part of a sphere of less diameter than the yolk sphere (Fig. 15). The formation of the germinal disc in both unfertilized and fertilized eggs may thus be divided into three periods, during the first of these, lasting about ten minutes it increases in size and takes on a definite watch glass form. During the second period, the hour during which the polar bodies are being formed it remains practically without change of form. During the third period, extending from the time of intrusion of the second polar body to the third hour (about) it passes gradually from the watch glass form to the form of a segment of a sphere of gradually lessening radius.

B.—SECTIONS.

While the polar bodies are forming and the germinal disc accumulating changes of the greatest importance are taking place on the inside of the germinal disc and must be studied by means of sections.

My own observations extend only over the period covering the formation of the first polar body and are even here incomplete. I shall therefore draw mainly on the accounts that have been given by Agassiz and Whitman ('90) and Boehm ('91) and shall refer to those of Kupffer. The account given by Hoffman, for reasons previously stated, I shall not make use of, and that of Blanc ('92) is not yet accessible.

Boehm, who worked on the trout, has given the most complete account of most of the stages. In sections made through discs *ten minutes after fertilization* he finds the nucleus of the egg in the mother star phase of karyokinesis. It consists of a distinct acromatic spindle with spindle fibres and about the equator of the spindle are grouped the chromatin threads. These have the form of short rods and will be spoken of as chromosomes. It may be said here that the loop or U form of the chromosome found in most dividing nuclei is not universal and that in the egg of the trout we have one exception in that the chromosomes are rod-shaped. Their number is about six.

Twenty minutes after fertilization (Fig. 34) the achromatic spindle (p. sp. 1.) has traveled to the surface of the germinal disc and lies with its outer pole against the surface and its long axis nearly perpendicular to the surface. At the same it has increased in size and the spindle threads are more distinct. The number of chromosomes (crm.) has now increased to about twelve, *i. e.*, it has doubled. Each of the twelve chromosomes is as long as the original but only half as thick.

Thirty minutes after fertilization it is found (Fig. 35) that in place of twelve chromatin rods at the equator of the spindle there are now twenty-

four shorter chromatin bodies, twelve near one pole of the spindle and twelve near the other pole. There can be no hesitation in saying that each of the twelve rods situated in the equator in the preceding mother star stage has divided into two, and that we have now the daughter star stage. The twelve chromosomes near each pole of the spindle continue to travel toward the poles and finally reach them (Fig. 36).

The outer pole of the spindle is then pushed above the level of the germinal disc (Fig. 36, p. b. 1.) so as to form an elevation on its surface. This elevation is the first polar body which we have already studied in the living egg. The outer pole of the spindle, together with the twelve chromosomes grouped about it is then pinched off from the germinal disc by a circular constriction which runs about between it and the disc. When thus pinched off (Fig. 36, p. b. 1) it forms the first polar body and lies in a depression on the surface of the egg so that its outer side is seen in the living egg.

The twelve chromosomes that remain in the egg arrange themselves about the equator of a new spindle which has been formed in the meantime (Fig. 37, p. sp. 2). The origin of this second spindle (second polar spindle) has not been determined in Toleosts. When the chromosomes have arranged themselves about its equator the nucleus is again in the mother star stage. The twelve chromosomes then again divide each into two and the twenty-four thus formed separate into two groups of twelve each which travel toward the poles of the second polar spindle and form thus a new daughter star stage (Fig. 37).

This in the trout is reached at the end of one hour ten minutes. The chromosomes continue to travel toward the poles which they finally reach, the outer pole is then pushed above the surface and a constriction forms which pinches it off together with twelve chromosomes about it. There is thus formed the second polar body (Fig. 38, p. b. 2). It is formed in the wall-eyed pike immediately beneath the first polar body and pushes the latter up out of the depression of the surface in which it lay. The second polar body then occupies this depression, but is after a time expelled from it by the obliteration of the depression and the two polar bodies then lie side by side on the surface of the egg.

The twelve chromosomes that are left in the egg after the expulsion of the second polar body now form a compact group composed of twelve spherical bodies, each corresponding to one of the chromosomes. This is all that is left of the egg nucleus (Fig. 38, at crm.). It remains for a considerable time attached by some of the spindle threads to the bottom of the depression in which the second polar body lies.

It is evident that by the process of forming the polar bodies three-quarters of the chromatin of the nucleus of the egg is extruded. Half of it is extruded in the first polar and half of the remainder in the second polar body. The mass of chromatin left in the egg at the end of the process is therefore only one-quarter what it was at the beginning of the process (compare Fig. 38 with Fig. 34). Not only is the mass of chromatin thus reduced by three-quarters, but the *number* of chromatic bodies or chromosomes is also reduced three-quarters. There are twelve chromatin bodies (chromosomes) in the equator of the spindle before the formation of the first polar body (Fig. 34). No one has described a division of the bodies in Teleosts, but what has been made out by Boveri for Ascaris and by Rückert in sharks is probably true here also, namely, that each chromosome consists in reality of four and that there are altogether forty-eight

chromosomes about the equator of the first polar spindle. When the apparent number increases from 12 to 24 in the formation of the first polar body* (Fig. 35) it is owing merely to a separation of twenty-four of the hitherto united chromosomes, which travel toward one pole of the spindle from the other twenty-four which travel toward the other pole of the spindle. The chromsomes composing each group of twenty-four are united together in pairs so that there appear to be but twelve chromsomes at each pole of the spindle (Fig. 36). The twelve near the outer pole of the spindle are then extruded (Fig. 36). Those remaining within the egg now separate on the second polar spindle into two groups of twelve each (Fig. 37), and the outer group is expelled in the second polar body. The result is that of the forty-eight chromosomes originally present in the egg but twelve remain. These twelve are now united into a spherical mass, the female pronucleus (Fig. 38 at crm.).

In the meantime the spermatozoön has entered the egg. Boehm finds that the micropylar canal contains a number of spermatozoa during the first hour and a half after fertilization (Fig. 35, spr.). The heads of these spermatozoa are found filling the canal as many as seven in a row and become deeply colored by the stains ordinarily used.

Thirty minutes after fertilization *one* of these heads is found in the germinal disc near its surface and close to the micropyle. One hour after fertilization the spermatozoön head is found (by Kupffer) lying still near the surface and consisting of four segments arranged in a row (Fig. 36a, spr.). On the inside of it is seen a star or sun (Fig. 36a, as.) made up of radiating lines in the cytoplasm and indicating the presence of a centrosome, though no centrosome is visible.

One hour and twenty minutes after fertilization (Fig. 38) Boehm finds that the spermatozoön has descended into the germinal disc and that the two constituents have separated from one another. The chromatic portion (m. pn.) has now the form of a group of rounded chromatin bodies which closely resembles the female pronucleus. The number of separate chromosomes composing it is not stated by Boehm but we may assume that it is, as in other animals, the same as the number in the female pronucleus, that is, twelve. The chromatic part of the spermatozoön is called the *male pronucleus.* In addition to this the sun-like or star-like figure previously described as having its center near the spermatozoön, is now separated from it by a considerable distance. It is called the aster and probably has at its middle a centrosome, though this has not been described (Fig. 38, as.).

Two and a half hours after fertilization the male pronucleus is at some distance from the central part of the aster (Fig. 39, mp. n.), while the female pronucleus (f. pn.) is still in the region of the polar body and is still united by very plain fibres (f. p.) with the bottom of the pit in which the polar body lies. Three hours after fertilization (Fig. 40) the male pronucleus (m pn.) is almost in contact with the center of the aster (as.). The female pronucleus (f. pn.) lies in the region of the polar body (p. b. 2) and fibres (f. u.) connect it with the surface. The impression made upon one at this stage is that the female pronucleus is being strongly attracted by the male pronucleus or the aster. It has moved from its original position and the fibres which hold it to the surface have been pulled out so that they are longer and they are at the same time bent toward one side. Both

* All the chromosomes are not visble in every figure since the deeper ones are often concealed by the more superficial.

male and female pronuclei show less distinctly than before a division into chromosomes and both show a tendency on the part of the chromatin to resolve itself into the network which is characteristic of the resting nucleus. This process has gone further in the male than in the female pronucleus.

Three hours and thirty minutes after fertilization (Fig. 41), the male pronucleus (m. pn.) lies on one side of the aster. It shows now a distinct chromatin network and a well defined nuclear membrane. The rays of the aster converge toward two points instead of one, in other words there are two asters (as. 1, as. 2). These have doubtless been derived by the division of the single aster of the earlier stage and each doubtless contains a centrosome. The female pronucleus (f. pn.) has now been drawn nearer the male and the threads connecting it with the surface have disappeared. Two or more of its chromosomes have separated from the remainder and lie near the female pronucleus, forming small separate accessory female pronuclei. The female pronucleus shows a distinct chromation network and a nuclear membrane.

Five hours and fifteen minutes after fertilization (Fig. 42) the two asters have separated from one another by a considerable distance and each is made up of a distinct set of rays (as. 1, as. 2). These two sets of rays come together at the sides of the asters and midway between their centers. In a direct line between the asters there are no aster rays and in this position are seen the two pronuclei. The male pronucleus (m. pn.) is now underneath (*i. e.*, furtherest form the surface) and shows a chromatin network and a distinct thick nuclear membrane. The female pronucleus (f. pn.) has been drawn up against the male pronucleus so that the two are in contact. It is larger than the male pronucleus with a distinct chromatin network and with a delicate nuclear membrane. The accessory pronuclei lie near it.

Seven hours and thirty minutes after fertilization (Fig. 43) the condition of things is still much the same. The two asters are present as before and between them the two pronuclei. The male pronucleus has scarcely changed and lies as before, deeper than the female pronucleus. The female pronucleus has grown larger, its chromatin network is more distinct and it is wrapped part way around the male pronucleus, though the two are still perfectly distinct.

The accessory pronuclei have disappeared and are believed by Boehm to have been taken up into the female pronucleus from which they came.

Boehm does not give the latter history of the pronuclei, but it is given by Agassiz and Whitman ('90) for Ctenilabrus.

They find the pronuclei lying against one another as described by Boehm (Fig. 44) the male pronucleus (m. pn.) above (*i. e.*, near the surface) and at the ends of a line passing between them the two asters.

A little later the boundary between the two pronuclei has dissapeared and there appears to be but a single nucleus lying between the two asters. In this the chromatin is collecting again into chromosomes. Very soon (Fig. 45) the chromatin has gathered itself into a number of distinct chromosomes and at the same time a spindle, the segmentation spindle (sg. sp.), has made its appearance between the two asters. The source of the spindle is not clear but the asters form its poles. The chromosomes are arranged about its equator; in short the nucleus is in the mother star stage. The nucleus thus formed by the junction of the male and female pronuclei is known as the first segmentation nucleus. The number of chromosomes that it contains has not been definitely made out in Teleosts.

but from what is known in other animals (*e. g.*, Ascaris) we safely conclude that in the trout it is the sum of the number found in the male and female pronuclei, *i. e.*, twenty-four, twelve from each pronucleus. If this is true half the chromosomes in the first segmentation nucleus are derived from the egg, *i. e.*, from the female parent and half from the spermatozoön, *i. e.*, from the male parent.

Very shortly (Fig. 46) it is noticed that the chromosomes have divided each into two and are separating into two groups as in the ordinary process of karyokinesis. Each group would contain therefore (in the trout) twenty-four chromosomes, and of these twelve would have come from the male and twelve from the female parent. When the groups of chromosomes are separated the nucleus is in the daughter star stage.

The separation continues until the groups have reached the poles of the spindles (Fig. 47) and two daughter nuclei (nu. 1, nu. 2) are formed, still united by some of the spindle threads (f. p.). Each daughter nucleus lies near one of the asters and at the center of each aster we may assume the existence of a centrosome. Very shortly (Fig. 48) a plane of division is formed in the cytoplasm, separating the cytoplasm into two cells each with its nucleus (nu. 1, nu. 2). Half of the chromosomes in each of these nuclei is of maternal origin and half of paternal origin.

The fish is now built up by the continued division of those two cells (as described in an earlier bulletin of the Michigan Fish Commission) and at each cell division the nucleus also divides. It is not the purpose here to enter into this process of the formation of the embryo and one thing only remains to be pointed out. In each of the cells of the body of the embryo the nucleus must be a lineal descendant of the first segmentation nucleus. It must contain therefore the same number of chromosomes as the segmentation nucleus and half of these must be maternal and half paternal.

The account just given is drawn exclusively from Boehm and Agassiz and Whitman, with a single point taken from Kupffer on Boehm's authority. I may add that I have made, in sections, observations covering the history of the first polar body and the formation of the male pronucleus but that these add nothing to what was previously known.

A resumé of the observed facts may not be out of place. We have seen in the living egg the formation of an impregnation eminence for the reception of the spermatozoön (as will be presently shown). We have seen during the time when the egg is filling and the germinal disc forming, that two polar bodies, minute spheres of protoplasm, are pinched off from the surface of the disc and lie in the perivitelline space where they afterwards probably go to pieces. After the formationof the polar bodies a period of one to two hours elapses during which the only changes visible externally are the changes in form of the germinal disc and the increase in size of the perivitelline space.

Turning to sections we have been able to make out that the formation of the polar bodies is accompanied by the usual karoykinetic process of division, so that each polar body contains a part of the egg nucleus. The formation of the polar bodies is an ordinary cell division twice repeated and differs from other cell divisions only in that in each case one of the cells formed (the polar body) is very small while the other (the egg cell) is very large. During the formation of the polar bodies we have seen the gradual penetration into the egg of the spermatozoön and its separation into two portions, a chromatic portion the *male pronucleus* and an achro-

matic portion the *aster*. We have seen the aster descend into the center of the germinal disc and then begins the most astonishing part of the process. The aster by some means attracts or pulls to itself the *male pronucleus* and at the same time draws to itself the remains of the egg nucleus, the *female pronucleus*. Each pronucleus is seen to be made up of twelve (?) chromatin bodies. By the continued attraction of the aster the pronuclei are brought together, the female near the surface and the male beneath it. In the meantime the aster has divided into two asters and the pronuclei have gone into the condition of resting nuclei. Very soon the pronuclei pass out of the resting condition, each shows again a division into 12 chromatic bodies of which it is composed, and at the same time a spindle appears between the two asters. This spindle has at each pole one of the asters and around its equator the twenty-four chromatin bodies, 12 from the father and 12 from the mother. An ordinary cell division follows and results in the division of the germinal disc into two cells, each containing a nucleus composed half of maternal and half of paternal chromatin.

These important changes going on within the germinal disc during the first hours of its existence show why it does not begin to divide into cells at once upon being laid.

C.—HISTORICAL AND CRITICAL.

I purpose here to touch upon only two points upon which, as it seems to me, my own observations throw some light.

1. *How many spermatozoa enter the egg?*

It is now conceded that normally not more than one spermatozoön becomes converted into a male pronucleus and joins with the female pronucleus to produce the first segmentation nucleus. It is known however from the researches of Rückert ('91) on sharks, of Oppel ('92) and Todari ('91) on Reptilia and those of Henking on Insecta, that in these forms a considerable number of spermatozoa enter the egg. Only one of these become converted into a male pronucleus while the fate of the others is uncertain, but it is believed by Rückert that in sharks they become the nuclei of the yolk.

In a recent paper Rückert ('92) has given good reason for the conclusion. Since the same nuclei (parablast nuclei) exists in Teleosts, the question of the number of spermatozoa penetrating the egg becomes at once important. Nearly all the writers who have made observations covering this point on living eggs agree that the spermatoza enter the Teleost egg by the micropyle. This has been observed by Ransom ('66) by Hoffman ('82), by List ('86), apparently by Hensen ('82), and by André ('75).

Boehm ('91), has described the spermatozoa in the micropylar canal of the trout (Fig. 35) in sections and His ('73) has shown such agreement between the size of the canal and the head of the spermatozoön that not more than a single spermatozoön could enter at one time. Agassiz and Whitman and Boehm who have studied sections of the germinal disc agree in describing but a single male pronucleus and do not mention any structures that can be regarded as heads of additional spermatozoa. My own sections have yielded the same results.

Kupffer ('86) as quoted by Rückert ('92) believed from the existence.

of a number of impregnation eminences in the trout that more than one spermatozoön entered the egg, but was unable to prove this by sections. Blanc ('92) has (according to Rückert) described the existence of a number of spermatozoa in the egg of the trout, especially when impregnation is performed by the Russian method. The implication is that the existence of more than one spermatozoön is not normal.

So far as the study of sections go then, they have shown that normally but a single spermatozoön enters the germinal disc in Teleosts. On the other hand we have the testimony of Kupffer ('77) from observations on the living egg, that in the herring a large number of spermatozoa enter the egg. *Kupffer did not see these spermatozoa passing through the zona radiata*, but saw them in the perivitelline space and in the yolk. He saw them in motion and describes the motion as exactly like that of the head of a spermatozoön. He did not see the tails with certainty. He found that the spermatozoa remained in motion in the perivitelline space for about nine hours and then disappeared. According to McIntosh and Prince ('90) Brook has also described the penetration of large numbers of spermatozoa into the egg of the herring.

I have not seen Brook's account, but Kupffer seems to me wholly insufficient to prove the point. I have shown the existence in the perivitelline fluid of the egg of the wall-eyed pike of granules, the motions of which are to all appearances identical with those of the heads of spermatozoa. Most of these granules are also identical in size with the heads of spermatozoa and it is certainly very easy to confound the two. I have shown that these granules exist in the unfertilized egg. It seems to me, therefore, that until Kupffer has either seen the spermatozoa in the act of passing through the zona radiata or has proved their possession of tails or has found them in sections of the germinal disc or has shown that they do not exist in unfertilized eggs his conclusions cannot be accepted. The exact observations upon which Brook's conclusions were based are unknown to me.

The existence normally of a single impregnation eminence in the wall-eyed pike indicates the penetration of a single spermatozoön. By Hertwig ('87) the existence in the sea urchin of several such eminences was found to mean polyspermy, the penetration of a number of spermatozoa. Kupffer is quoted by Rückert ('92) as describing several such eminences in the trout and as surmising from their existence the penetration of several spermatozoa in that form. I have twice seen more than one eminence in the wall-eyed pike, but must conclude that the cases were abnormal and that normally but a single impregnation eminence exists.

It seems to me a conclusion warranted by the facts so far observed, that in Teleosts but a single spermatozoön normally penetrates the germinal disc. That in exceptional cases several spermatozoa may penetrate the disc has been shown by Blanc.

2. *What is the meaning of the impregnation eminence?*

The impregnation eminence has been described in invertebrates by Fol and Hertwig and perhaps by others and indicated as the point of contact between the ovum and the spermatozoön.

Kupffer ('86) is stated by Boehm to have observed a number of eminences on the germinal disc of the trout and to have considered them as impregnation eminences and as indicating the penetration of more than one spermatozoön. This is the only observation among the Teleosts.

Boehm ('88) gives the first satisfactory account of this eminence for any

vertebrate in the lamprey eel. He describes a mass of clear protoplasm, the pole plasm, as spread out in a thin layer over a considerable area on one pole of the egg. Over the pole plasm is an area of the shell through which spermatozoa may penetrate, but elsewhere they are prevented from penetrating by a secretion covering the egg shell. There is no micropyle. Shortly after fertilization the pole plasm is raised up into a large rounded elevation (the impregnation eminence) which is found to contain the head of the spermatozoön and also the provisional egg nucleus. The eminence then rises up until it touches the shell, undergoes changes of form and is believed by Boehm to take up the inner ends of a number of spermatozoa that have penetrated the shell far enough to allow their inner ends to project into the perivitelline space. The eminence is then withdrawn. The pole plasm persists and sinks into the egg, following the retreat from the surface of the pronuclei. In it take place the phenomena of fusion of the pronuclei and the formation of the first segmentation nucleus. This pole plasm is believed by Boehm to be the more fluid portion of the *egg nucleus.* The point of particnlar interest in this connection is the fact that the pole plasm is first spread over all that part of the surface of the egg to which spermatozoa have access and that the eminence which later projects from it is of large size.

Schultze ('88) has described the fovea germinativa (previously noticed by others) a light colored spot near the middle of the dark pole of the eggs of frogs and other amphibia. From the fovea the polar bodies are given off. Schultze regards the fovea as formed by the more fluid portions of the egg nucleus at the time of formation of the first polar spindle. Schultze says nothing as to the relation of the fovea during the act of fertilization. It is morphologically the same as the pole plasm of the lamprey eel and might be expected like the pole plasm to receive the spermatozoön.

Roux ('87) has, however, shown that the penetration of the spermatozoön may take place in the frog along any meridian of the egg and he was able to vary the point at which the spermatozoa entered the egg by varying the point of application. In the amphibia, therefore, the fovea is not necessarily an impregnation point.

Ruckert ('92) in sharks, and *Oppel* ('92) in Reptilia have both described the point of entrance of spermatozoa into the germinal disc as marked by a depression of the outer surface. The spermatozoa may enter the disc at any point over a considerable area since there is no micropyle.

I know of no other references to the subject among vertebrates. From this review it appears that in the vertebrates investigated the entrance point of the spermatozoön may be marked by a depression of the surface protoplams or by both an elevation of the protoplasm and a depression as in the case of the wall-eyed pike. In those cases (sharks, Amphibia and Reptilia) where the area of the egg to which the spermatozoa may get access is considerable there is no special accumulation of clear protoplasm (pole plasm) and no special impregnation eminences have been described. In the two cases where the area of the egg to which spermatozoa get access is small (bony fishes, lamprey eel) there is an elevation (impregnation eminence) formed, *and the size of this eminence is in proportion to the size of the impregnation area.* Thus in the lamprey eel the eminence (or the pole plasm) covers the whole of the area of the shell, through which it is possible for spermatozoa to pass, an area which to judge from Boehm's figures, has a diameter equal to about one twelfth the circumference of the

egg. The contact of the egg with the spermatozoön may take place over any part of this area. In the wall-eyed pike on the other hand, the impregnation eminence is very small and covers only that part of the area of the disc which is in contact with the micropylar eminence. This is, according to nearly all observers, the whole area to which it is possible for spermatozoa to get access. This area and this only is normally elevated into a single impregnation eminence and the eminence bears at its top a single small depression. This indicates very clearly that here but a single spermatozoön penetrates the egg.

From the fact that the eminence exists in the fertilized but not in the unfertilized egg we may conclude that it is formed by the protoplasm of the disc in response to the stimulus produced by contact with the spermatozoön. It may probably be interpreted as an attempt on the part of the egg to enclose and surround the spermatozoon as quickly as possible and to thus withdraw it from the surface. Whether it is formed from any part of the nucleus of the egg is wholly unknown, but is unlikely.

The impregnation eminence may be regarded as fixed simply in relation to the micropyle. If by any chance more than a single spermatozoön should get access to the egg (as in cases observed by Blanc) there would doubtless result a number of impregnation eminences. The impregnation eminence is not therefore to be regarded as a contrivance for preventing the entrance of more than one spermatozoön, but as an adaptation to another contrivance which does thus prevent the entrance of more than one spermatozoön. That contrivance is the micropyle.

3. *The function of the micropyle:*

As already shown the testimony nearly all shows that the spermatozoön enters the egg at only one point, the micropyle. Attempts have been made to show that the micropyle is closed after the entrance of the first spermatozoön, so that a second one cannot enter. Thus Calberla ('77) thought he had shown that in the lamprey eel the penetrating spermatozoön left its tail in the micropyle and thus closed it against other spermatozoa. Boehm ('88) later showed that there is no micropyle in the lamprey eel, but that the spermatozoön enters at any point over a considerable area of the egg *and carries its tail with it.*

Hoffmann ('82) believed that he had shown that in certain species of Teleosts the micropyle was plugged by the first polar body and the entrance of a second spermatozoön thus prevented. But Agassiz and Whitman ('90) showed that the extrusion of the polar bodies through the micropole is an exception, and that regularly they remain in the perivitelline space. This conclusion has since been verified by Boehm and by myself. There is probably therefore no mechanical plugging up of the micropyle to prevent the entrance of a second spermatozoön.

Hoffmann ('82) has suggested that the micropyle may be closed by the formation of the perivitelline space. The micropyle opens internally at the apex of an elevation of the zona and the formation of the perivitelline space must cause some pressure to be exerted on the inside of the shell. Any such pressure on the end of the micropylar projection would, according to Hoffmann, tend to close the canal. This one may illustrate by punching a hole through a piece of cardboard with a pencil point or other conical instrument, as already suggested. There is thus formed a canal through the cardboard and like the micropylar canal one end of it is at the apex of a conical elevation of the substance of the cardboard. This elevation is on the side of the cardboard opposite to that to which the

punch was applied and it is easy by any pressure against it to close the opening formed. It was doubtless in some such way as this that Hoffman pictured to himself the closure of the micropylar canal by pressure within the perivitelline space.

André ('75) had however previously performed experiments indicating that the micropyle remains open. Owing perhaps to the misleading title of his paper it has been generally overlooked. He cut the egg shell of the trout in halves and floated the halves on the surface of water. He found that the half which contained the micropyle filled and sank, while the other half remained floating and he explained this by supposing that water entered the micropyle and filled the half of the shell which contained it. He floated other halves on ammonia water and placed on the inside of each piece a little carmine. In the half containing the micropyle the ammonia entered and disolved the carmine, while it did not enter the other half of the shell. He floated entire eggs in solutions of carmine and found that the carmine stained the inside of the egg, in the region of the micropyle. From these observations he concludes that the micropyle is an open passage way.

In criticism of this it may be said that it shows only that fluids pass through the shell in the region of the micropyle. The shell is thinner in this region and might admit fluids here though not elsewhere. In spite of this criticism the evidence strongly favors the conclusion that the micropyle is open.

There is one other set of facts bearing on this question, namely, that it is not possible to fertilize eggs of wall-eyed pike that have lain in water. This is shown by the following experiments. Five lots of eggs of twenty-five eggs each were prepared for fertilization by placing them in watch glasses in the usual way and to each lot, after it had been a certain time in water, was added freshly prepared milt, as follows:

	Milt added after	Fertilized, *i. e.*, segmented.	Unfertilized.	Percentage of fertilized eggs.	Number injured.
Lot 1	2 min.	10	15	40	0
" 2	4 "	3	15	17	7
" 3	6 "	2	18	10	6
" 4	8 "	1	18	5	6
" 5	10 "	0	16	0	9

In each case the milt was washed off after one minute and fresh water added. The milt was tested both before the experiment began and again two or three minutes afterward and was found to be normally active in water. In calculating the percentage the injured eggs are excluded, since it was impossible to tell whether or not they had been fertilized. The experiment illustrates (what had been known since Costé) that lying in water makes the eggs incapable of fertilization. Even two minutes in water has some effect; beyond four minutes the effect is enormous and at ten minutes not an egg is capable of fertilization. This might at first sight be accepted as evidence of the closure of the micropyle by the formation of the perivitelline space, but there are two reasons why it cannot be so accepted.

If the micropyle becomes gradually smaller it would *suddenly* pass the size at which it is possible for a spermatozoön to enter. If one were

attempting to fit a peg into a series of holes of diminishing sizes it might go into holes of sizes 1, 2 and 3 and not at all into sizes 4, 5 and 6. If there were twenty-five holes of each sort the percentage into which the peg could be fitted would run:

Holes.	Percentage.
1	100
2	100
3	100
4	0
5	0
6 and following	0

In the same way if the micropyle is diminishing in size there must come an instant of time when it is too small for the spermatozoa to enter. Previous to that time the percentage of fertilization must be high, subsequent to that time the percentage is nothing. This is true if the spermatozoön is regarded as a rigid body which cannot squeeze through an opening of gradually diminishing diameter. There is no evidence that the spermatozoön can thus squeeze through an opening smaller than its head. Our table of percentages of fertilization shows not a sudden transition but a gradual one from 40% to 0% and indicates not a suddenly developed cause like a diminishing micropyle, but a gradually developed cause. It indicates not that the closure of the micropyle but some other cause prevents fertilization.

If now we can find the effect of lying in water on the fertilization of some egg that has no micropyle we may be able to determine this cause. The egg of the lamprey eel is such a one. It has no micropyle (Boehm) and according to Calberla ('77) is capable of fertilization in water up to the time when the perivitelline space is formed. (It may lie nine or ten hours in water before the space forms.) After the formation of the space the egg cannot be fertilized. This indicates not the closure of a micropyle but the formation of the perivitelline space as the factor that prevents fertilization. The same phenomenon is observed in the egg of the frog which has no micropyle and is yet incapable of being fertilized after lying in water. Whether it is the perivitelline space itself that thus prevents fertilization or whether it is some subtle change in the germinal disc induced by contact with the water is undetermined.

With regard to the micropyle we may say that there is no evidence to show that it closes.

Why then is it, if the micropyle does not close, that no more than one spermatozoön normally enters the egg? I believe the answer is to be found in the narrowness of the micropylar canal and in the speedy death of the spermatozoa in water. No more than one spermatozoön can enter the micropyle at one time. This one must then travel the length of the micropylar canal in order to come in contact with the germinal disc. By the time it has reached the germinal disc it is likely that the other spermatozoa will have been killed by the action of the water. The only authenticated cases in which more than a single spermatozoön has been observed in the germinal disc of bony fishes are those cited by Blanc in the trout. Blanc states that more than one spermatozoön was found particularly in the case of eggs fertilized by the dry (Russian) method. In this method the fertilization takes place without the addition of water and the spermatozoa move in the fluid which bathes the eggs when they

are extruded. In this fluid, as I have shown, the spermatozoa live for an hour or more and there is therefore abundant opportunity for more than one spermatozoön to pass down the micropylar canal.

From what we now know of the eggs of sharks and reptiles it is by no means certain that the penetration of more than one spermatozoön into the egg would do harm. The occurrence of polyspermy as a physiological process may be considered established by Rückert ('92). We may well believe therefore that if there were no micropyle in the egg of a bony fish or if there were a dozen and a dozen spermotozoa were able to enter at one time no harm would result and the subsequent processes would go on as usual.

What then is the function of the micropyle? The question as it seems to me has been answered by Mark ('90). It is necessary that the egg should be protected against the fungus and other enemies and it is necessary at the same time that the spermatozoön should enter it. There are doubtless many ways in which these two objects may be accomplished. In bony fish the protection is afforded by a firm egg shell through which the spermatozoa cannot pass. Through this there must therefore be an opening. The greatest amount of protection is afforded when this opening is as small as it is possible to have it and still afford entrance for the spermatozoön. The size of the micropylar canal therefore is that of the head of the spermatozoön, and the egg thus enjoys the greatest amount of protection while still meeting the needs of fertilization. The function of the micropyle then is to allow the entrance of the spermatozoön. Its small size is not a contrivance developed in order to prevent the entrance of other spermatozoa, but rather in order to afford protection to the egg. That this small size taken in connection with the short life of the spermatozoa does prevent the entrance of a second spermatozoön, is an accompanying phenomenon, which in the present state of our knowledge, we may regard as of secondary importance.

D.—THE MEANING OF FERTILIZATION AND MATURATION.

The nucleus controls the cell and determines its character, whether muscle cell or bone cell or nerve cell. The character of an animal is determined by the cells which make it up and these in their turn are derived from the fertilized egg by repeated division. In the cell nucleus it is believed to be the chromatin which plays the important role and determines the character of the cell. In the fertilized egg it must be equally the chromatin which determines the nature of the animal to be derived from the egg. This chromatin we now know to come half from the mother and half from the father and we can thus understand the inheritance by a descendant of qualities derived from both mother and father. It has been shown experimentally by Boveri that if the nucleus be removed from an egg by shaking and if the egg be then fertilized, it develops, but the animal resulting from that development inherits none of the qualities of the mother (since the maternal chromatin has been removed from the egg) but only the qualities of the father.

The fertilization of the egg then leads to the production of a cell, the fertilized egg, the chromatin of which is half maternal and half paternal in its origin. The fertilized egg by repeated division gives rise to a new animal and in each cell of the new animal there is still a mingling in equal quantities of chromatin derived from father and from mother. We have

then in the phenomena of fertilization an explanation of the fact of heredity.

What meaning is to be attached to the polar bodies? There are but two answers to this question. The first asserts that the polar bodies are without meaning; that they are mere reminiscences of a time when each egg was wont to divide into four. That at present this division of the egg into four is still carried out, since the first polar body frequently divides into two, but that one only of the four eggs thus formed is laden with food material and large enough to develop an embryo. The polar bodies are accordingly regarded as aborted eggs, no longer of any use to the animal.

The other answer (that of Weismann) is that the polar bodies are of the greatest importance to the species, since their formation makes it certain that no two animals shall be exactly alike. Although a child resembles its parents it is never exactly like either parent and may be different from both. Perhaps this may be best illustrated by taking the concrete case of the egg of a bony fish as worked out by Boehm and combining it with what has been made out by Rückert ('92) and Boveri ('90). The case which I shall suppose for the purpose of illustrating Weismann's theory of the polar bodies is an ideal one, but the individual facts, as I shall suppose them to be, have all been paralleled in actual observations.

We may suppose to start with that the ordinary cell of a trout contains (as it almost certainly does) twenty-four rods or loops of chromatin, twenty-four chromosomes. These chromosomes are not to be thought of as identical, but each is different from all the others and the individual peculiarities of the cell are dependent on the influences exerted on it by these chromosomes. We may suppose that these twenty-four different sorts of chromatin are thus contained in any cell of the body of the trout and that the combined action of these makes the cell what it is. The egg cell and sperm cell likewise contain each twenty-four chromatin bodies. If an animal were to be developed from the egg cell without fertilization, each of its cells resulting from the division of the egg cell would contain the twenty-four chromosomes and the individual peculiarities of the animal would be determined by the kinds of chromatin which its cells contained. If on the other hand the egg is fertilized and if without the formation of polar bodies the twenty-four chromosomes of the egg have added to them twenty-four coming from the spermatozoön, the result is forty-eight chromosomes in the fertilized egg. This egg develops into a fish whose eggs would contain each forty-eight chromosomes and when fertilized without the formation of polar bodies would contain each ninety-six chromosomes. If the process of fertilization were thus to go on from generation to generation without the formation of polar bodies, the number of chromosomes in the fertilized egg and in the cells of the animal developed from it would be doubled in each generation and would soon become enormous.

Evidently there most be some means of reducing the number of chromosomes in the egg and in the spermatozoön before the two are brought together.

In the case of the egg this reduction takes place by the formation of the polar bodies, and in the spermatozoön there is a corresponding process gone through with. Thus every cell of the body of the trout contains twenty-four chromosomes, but the egg after it has formed the polar bodies contains but twelve, and as we have seen the male pronucleus derived from the sparmatozoön contains also but twelve. When the egg is fertilized therefore it contains twenty-four chromosomes and each cell of the young

fish that develops from it contains also twenty-four, the number present in the cells of both parents.

Polar body formation and the corresponding process in the spermatozoön is therefore a means of reducing the number of chromosomes in egg and spermatozoön before fertilization and of thus keeping the number constant in the cells of the body in successive generations.

The forty-eight (there are forty-eight, since each of the twenty-four is doubled) chromosomes found in the egg before the formation of the polar bodies are not to be considered as alike; each is different from the others. We may designate them by numbers from one to forty-eight. In the formation of the polar bodies it may happen that numbers 1 to 12 are retained in the egg and numbers 13 to 48 extruded in the polar bodies, or numbers 37 to 48 may be retained and numbers 1 to 36 extruded or any other combination may take place. Of a dozen or a hundred or a thousand eggs that have formed their polar bodies probably no two will be alike. In one egg will be chromosomes 1 to 12, in another, 13 to 24, in another 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, and in each of the others various other combinations.

If there are twelve chromosomes (each double) in the nucleus of the egg before the formation of the polar bodies Weismann ('91) has calculated that the number of possible combinations is 8,074. That is by the formation of polar bodies from these eggs it is possible to obtain eggs with 8,074 different combinations of chromosomes in the nuclei. With 20 (double) chromosomes in the egg the number of possible combinations rises to 184,756.

What is true of the eggs is true also of the spermatozoa, so that with twelve chromosomes in the cell from which the spermatozoön is formed there is, as a result of that process in the spermatozoön corresponding to the polar body formation in the egg, a possibility 8,074 different kinds of spermatozoa.

When the spermatozoa and ova unite in fertilization the twelve chromosomes of the one are brought into the same nucleus with the twelve chromosomes of the other and the character of the individual peculiarities of the resulting animal are determined by the combination. Between the 8,074 sorts of ripened eggs and 8,074 sorts of spermatozoa there are possible 8,074 times 8,074 combinations, *i. e.*, 65,189,476 different sorts of fertilized eggs. This means that the chromosomes in the nucleus of a fertilized egg will rarely or never be just the same sorts as those in any other egg at the same time. From each sort of egg will develop an animal with its own individual peculiarities differing in some way from the peculiarities of any other animal of the same species.

In the formation of polar bodies we have then an explanation of the fact, so often observed that no two animals are ever exactly alike. The old adage has it "As alike as two peas" but two "peas" were probably never exactly alike.

These variations are according to this theory the variations upon which natural selection must act in producing new species.

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EXPLANATION OF PLATES.

The following letters have the same meaning in all the plates:

as, aster.
as^1, as^2, polar asters.
c. dr, cortical drops.
cl. 1, cl. 2, two cells formed by the first segmentation furrow.
cn, centrosome.
con, cone of cytoplasm threads.
cv, cortical layer or cortex.
crm, chromosome.
cyt, cytoplasm.
e. m, external egg membrane.
f. u, uniting fibres.
f. pn, female pronucleus.
g. d, germinal disc.
gl, globule closing micropyle.
gr, groove between edge of germinal disc and yolk.
i. em, impregnation eminence.
m. cl, cell membrane or cell wall.
m. nu, nuclear membrane or nuclear wall.
m. pn, male pronucleus.
my, micropyle.
my. c, micropylar canal.
my. e, micropylar elevation.
my. f. micropylar funnel.
nu, nucleus.
nu. 1, nu. 2, nuclei of the two cells formed by the first segmentation furrow.
o. d, principal oil drop.
o. d^1, smaller oil drop.
p. b, 1, first polar body.
p. b. 2, second polar body.
p. b. 1 and 2, first and second polar bodies.
p. c, pore canals.
prt, partition walls between cells.
p. sp, 1. first polar spindle.
p. sp. 2, second polar spindle.
pv, perivitelline space.
pv. f, perivitelline fluid.
sg. sp, first segmentation spindle.
sp, spindle.
spz, spermatozoön.
z. r, zona radiata.
yk, yolk.
1, chromosome no. 1.
2, chromosome no. 2.
1^1, daughter chromosome derived from 1.
2^1, daughter chromosome derived from 2.

The divisions on the scales which accompany the drawings are tenths, hundredths and thousandths of a millimeter (mm.) One mm. equals about $\frac{1}{25}$ of an inch, hence .1 mm. equals $\frac{1}{250}$ in. .01 mm. equals $\frac{1}{2500}$ in. and .001 mm equals $\frac{1}{25000}$ in.

PLATE I.

Fig. 1.—Diagram of resting cell, original.
Fig. 2.—Diagram of cell with nucleus in the early mother skein stage. Only a small part of the cytoplasm is represented.
Fig. 3.—Diagram of cell with nucleus late in the mother skein stage. In this and the following figures except Fig. 8, the cytoplasm is not drawn in detail.
Fig. 4.—Diagram of cell with nucleus in the mother star stage.
Fig. 5.—Diagram of cell with nucleus in metakinesis.
Fig. 6.—Diagram of cell with nucleus in the daughter star stage.
Fig. 7.—Diagram of cells just divided with nuclei in daughter skein stage.
Fig. 8.—Diagram of two cells recently separated. In the upper cell the nucleus in daughter skein stage, in the lower cell the nucleus passing into the resting condition.
Figs. 2, 3, 4, 5, 7, are diagrams suggested by the figures of Boveri and the diagrams of Rabl. *Fig. 8* is copied from Waldeyer, a centrosome has been added in the lower cell.

PLATE II.

Fig. 9.—Diagram of an egg as it leaves the body of the fish (before contact with water) magnified sixty diameters.
Fig. 10.—Egg as it leaves the body of the fish and before contact with water. The details are filled in over one-half of the egg.
Fig. 11.—The egg shown in Fig. 10 after having been fertilized and having been two minutes in water. The yolk and the oil drop are represented only in outline. Same scale as Fig. 10.
Fig. 11a.—Part of the germinal disc of the same egg *five minutes* after Fig. 10, showing the impregnation eminence and the granular eminence. Same scale as Fig. 10.
Fig. 12.—The egg shown in Fig. 10 *seven minutes* after contact with water. In this figure and in Figs. 13, 14, and 15 the zona radiata, the yolk and the oil drop are represented only in outline.

Fig. 13.—The egg shown in Fig. 10 *about one hour* after contact with water. The first polar body is formed.

Fig. 14.—The egg shown in Fig. 10 *two and a half hours* after contact with water. Both polar bodies are shown.

Fig. 15.—The egg shown in Fig. 10 *three hours* after contact with water. The polar bodies did not show. The first segmentation furrow appeared four hours twenty minutes after fertilization.

Fig. 16.—Diagram of an egg in a condition similar to that of the egg shown in Fig. 15. The polar bodies are shown and the male and female pronuclei and the aster appear in the germinal disc. Magnified about sixty diameters.

Fig. 17.—A spermatozoön.

The numeral attached to the scale of this figure should be .001.

The figures are all original and from the wall-eyed pike. Figs. 10, 11, 12, 13, 14, 15, were drawn from living eggs from outlines with the Abbé camera under Zeiss's apochromatic 16 mm. Ocular 2, with the paper elevated considerably above the level of the microscope stage. Fig. 17 was drawn with the Abbé camera under Zeiss's apochromatic 2 mm. ocular 12, and was afterward enlarged.

PLATE III.

Fig. 18.—A part of the cortical layer near the edge of the germinal disc, together with the egg shell and perivitelline space. Section.

Fig. 19.—Sections of the egg shell treated by the Berlin-blue process. The canals and the perivitelline fluid which are represented as black, are blue in the preparation.

a. Cross section from an egg preserved in Perenyi's fluid.

b. Tangential section from an egg preserved in Perenyi's fluid.

c. Cross section from an egg preserved by Hoffmann's method.

Fig. 20.—Diagram of the micropyle as seen in the living egg a few minutes after contact with water.

Fig. 21.—Cortical drops and small oil drops from the surface of the large oil drop in a living egg, to show the difference in optical effect between the cortical drops and oil drops.

Fig 22.—A piece of the cortical layer of a preserved egg containing cortical drops. The minute granules composing the drops are shown over a part of one of them.

Fig. 23.—Four successive stages in the formation of the same impregnation eminence as seen in the living egg. The earliest stage is at the bottom (*d*). A part of the zona radiata with the micropyle is represented in its natural position above the upper figure (*a*).

Fig. 24.—Part of the germinal disc with granular eminence and impregnation eminence and of the zona radiata with micropyle. An oblique view from the living egg. Scale unknown.

Fig. 25.—Sketch of part of a living egg, showing the micropyle closed by a protoplasmic globule.

Fig. 26.—Part of a living egg showing the impregnation eminence five minutes after fertilization.

Fig. 27.—Part of another living egg showing impregnation eminence and granular eminence, five minutes after fertilization.

Fig. 28.—Part of a living egg showing the two polar bodies.

Fig. 29.—Two views of the polar bodies in a living egg, *a* is a little later than *b* and shows the first polar body falling from the top of the second. Same scale as Fig. 33.

Fig. 33.—Part of a living egg showing the two polar bodies.

The figures are all original and with the exception of Figs. 20, 25, and 29, which are sketches, were drawn under Zeiss's apochromatic objectives with the aid of the Abbé camera.

PLATE IV.

Fig. 34.—Part of section through the germinal disc of an egg of the rainbow trout, *twenty minutes* after fertilization.

Fig. 35.—Part of section through the germinal disc and zona radiata of the rainbow trout, *thirty minutes* after fertilization.

Fig. 36.—Part of a section through the germinal disc and zona radiata of the rainbow trout, *one hour* after fertilization.

Fig. 36a.—Part of a section through the germinal disc of the trout *one hour* after fertilization, showing the condition of the spermatozoön.

Fig. 37.—Part of a section through the germinal disc of the rainbow trout, *one hour and ten minutes* after fertilization.
Fig. 38.—Part of a section through the germinal disc of the rainbow trout, *one hour and twenty minutes* after fertilization.
Fig. 39.—Part of a section through the germinal disc of the rainbow trout, *two hours and thirty minutes* after fertilization.
Fig. 40.—Part of a section through the germinal disc of the rainbow trout, *three hours* after fertilization.
Fig. 41.—Part of a section through the germinal disc of the rainbow trout, *three hours and thirty minutes* after fertilization.

The figures are all copied from Boehm ('91) and were four times the size of the original figures, but have been subsequently reduced by photography. The first polar body is not shown in Figs. 38, 39, 40 and 41, but may be thought of as lying on the surface of the disc near the second polar body.

PLATE V.

Fig. 42.—Part of a section of the germinal disc of the rainbow trout, *five hours and fifteen minutes* after fertilization.
Fig. 43.—Part of a section of the germinal disc of the rainbow trout, *seven hours and thirty minutes* after fertilization.
Fig. 44.—Vertical section of the germinal disc of Ctenilabrus, showing the two pronuclei. Magnified 1120 diameters.
Fig. 45.—Vertical section of the germinal disc of Ctenilabrus, showing the first segmentation spindle (mother star stage).
Fig. 46.—Vertical section of the germinal disc of Ctenilabrus, showing the first segmentation spindle (metakinesis).
Fig. 47.—Vertical section of the germinal disc of Ctenilabrus, showing the division of the first segmentation nucleus.
Fig. 48.—Outline of a vertical section of the germinal disc of Ctenilabrus, after the formation of the first segmentation furrow. The segmentation nucleus is divided into two.

Figs. 42 and 43 are from Boehm ('91) and were drawn four times the size of the original. Figs. 44, 45, 46, 47, 48, are from Agassiz and Whitman and are four times the size of the originals, except Fig. 48, which is somewhat smaller. These figures have been subsequently reduced by photography. The nucleus in Fig. 45 is represented by Agassiz and Whitman in a surface preparation, but is shown here in section to harmonize it with the other figures.

OLD AND NEW SUGGESTIONS CONCERNING ARTIFICIAL FERTILIZATION, WITH A METHOD OF HANDLING ADHESIVE EGGS.

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The preceding account affords an opportunity of restating some long known but apparently little heeded precautions that must be observed to secure good results in artificial fertilization. At the same time it yields some new facts that may be at once turned to practical account, and it has resulted in devising a means of handling adhesive eggs that it is hoped is of practical value.

1. The milt (of wall-eyed pike or whitefish) that has been mixed with water for one minute should not be used in fertilizing eggs.

The reason for this, as pointed out in the preceding paper, is that a large proportion of the spermatozoa are dead in water at the end of a minute. This fact has long been known but has certainly not always been heeded by practical fish culturists. It holds true as far as observed for all fish that spawn in fresh water, but the time has not previously been determined for the two species named.

2. The milt may be kept in good condition for several hours in almost any sort of receptacle, provided it is not mixed with water. This fact has also been long known. It may at times be of practical value when the male fish are not to be obtained in sufficient numbers at the same time or same place with the females. Milt could be then collected at some other time or some other place and kept or transported.

3. The milt kept as above will retain its vitality longer if kept cold; it may even be frozen. The spermatozoa in the testes remain active longer than those in the milt (Quatrefages).

4. The eggs should not be washed before being brought into contact with the milt. The washing removes the fluid which bathes the eggs when laid and this fluid serves the purpose of attaching the spermatozoa temporarily to the egg and of thus facilitating fertilization.

5. The egg should not lie in water for any length of time before fertilization. It was pointed out in the paper that eggs that lie in water

become rapidly incapable of fertilization, owing to the formation of the perivitelline space. This fact has been known since Costé. The table given in the paper shows the rate at which the wall-eyed pike egg becomes incapable of fertilization.

6. The eggs of the wall-eyed pike should not be allowed to lie for more than a few minutes in water containing milt. This water is alkaline, does not dissolve the cortical drops and eggs that have been subjected to its action for any length of time do not form a germinal disc and do not afterward develop.

The following experiment will serve to illustrate this: A batch of perfectly fresh eggs was fertilized. A dozen eggs were removed at once to a watch glass and washed and were kept under observation. The formation of the perivitelline space and polar bodies went on normally and at the end of two hours and forty minutes the eggs were all undergoing the first segmentation.

The remaining eggs were left in the diluted milt and were then washed up and left for twenty-four hours in clear water. Twenty-six eggs were then taken at random and of these one was found developing normally. The others were only partly "filled," the germinal disc was not formed and only half the whole number of cortical drops was dissolved.

In another experiment the eggs were divided, after fertilization, into two batches; one of these was washed up at once and placed in clear water, and the other left for two hours in the dilute milt and then washed up. About four hundred eggs of those washed up were examined and showed 96 per cent of fertilized and developing eggs. About one hundred and twenty-five of those left in the milt were examined and showed only 14 per cent of fertilized and developing eggs. The eggs in this batch that were not developing were found to be only partly filled, to contain many cortical drops and only an imperfect germinal disc. They were kept under observation for twenty-four hours and did not develop further.

In each of the experiments detailed above the eggs in the two batches were from one fish and were fertilized with the same milt. The only difference in their treatment was in the immediate removal of the milt in the one case and its remaining in the other case.

Whether the same results would follow with the eggs of other fish is uncertain. It would certainly be bad practice to allow the eggs of any fish to lie in milted water for more than five minutes without having previously determined this point.

7. The eggs should not be shaken.

With adhesive eggs, one means of preventing adhesion is to keep the eggs in motion. The following experiment was made to test the effect of this treatment. A lot of eggs were fertilized and divided into two batches. Both were washed up, but one was allowed to stand quietly and the other kept in motion somewhat vigorously in a shallow glass dish for half an hour. The motion was perhaps rather more violent than that which the men are accustomed to give to the eggs in the pails in order to keep them from adhering. After the eggs had begun to segment those in both batches were counted with the result that the eggs not shaken showed thirty-six per cent more fertilized eggs than those shaken. This was not due to visible mechanical injury to the eggs that were shaken, since the number of injured eggs was only one 1 per cent more than among those that were not shaken. The experiment was repeated with the same results, but with less violent shaking the percentage of unfertilized eggs was less. The only

explanation of the matter that occurs to me is that the shaking causes the germinal disc to strike against the egg-shell and so injures the impregnation eminence. Since this eminence no doubt contains the spermatozoön its injury results in the egg remaining unfertilized.

Under the limitations above pointed out artificial fertilization may be carried out in a number of ways, and indeed the practice varies among practical workers. If the milt is abundant and fluid, doubtless a good method is to take the eggs into a dry vessel and add the milt to them, shaking the eggs enough to mix the milt with them. Water may then be added and after two or three minutes the milt may be washed off by fresh water and the eggs allowed to stand quietly.

When the milt is scant in quantity and viscid so that it does not mix readily with water, it may be better to first mix the milt very rapidly with a small quantity of water and then add the eggs to this. In the case of the wall-eyed pike, not more than thirty seconds should elapse between the time when the milt touches the water and the time when the eggs are added. This can best be done when the spawner and milter are both ready at hand before the operation is begun.

A second method with scanty milt is to add the eggs first to the water and then add the milt. The advantage here is that the egg retains the power of being fertilized longer in water than the spermatozoön retains its fertilizing power. The disadvantage is that the albuminous fluid covering the eggs is at least partly washed off and one element which insures fertilzation is thus diminished in value. Of these two methods the first is to be preferred if one can work quickly enough, the second where there is any doubt as to the rapidity of ones movements.

Of course it is possible to take eggs and milt dry in separate dishes and then mix them with the addition of water at the same time. This is the ideal method and the nearest imitation of the natural process but is too cumbersome for actual practice.

Any of the methods here outlined require some modifications in case of the adhesive eggs of the wall-eyed pike.

Experience has shown that these eggs may be kept from adhering either by letting them lie in the milt for an hour or two, or by keeping them in continual motion, or by a combination of both processes. It has been shown that all of these processes are injurious.

It was therefore a desideratum to find a method by which it might be possible to wash the milt from the eggs immediately and to allow them to stand quietly in fresh water and still to obtain the eggs finally uninjured and not adherent to one another or to foreign objects.

It seemed that this might be accomplished in any one of three ways. 1. Some substance might be dissolved in the water, which, without injuring the egg or spermatozoön, might still so act on the external egg-membrane as to destroy its adhesive properties. It is known that the spermatozoa live in weak solution of various substances and that eggs are not readily killed by many such solutions. A considerable number of such substances was tried in very weak solution. Among them were common salt, chromic acid, chromic acid combined with salt, ammonium hydrate, potassium hydrate, sodium carbonate, sodium sulphate and egg albumen. All the experiments were fruitless and it is not necessary to detail them here. A mixture of salt and chromic acid destroys the adhesion of the egg permanently but the spermatozoa do not live well in it and the egg does not fill after its action.

2. It might answer to allow eggs to adhere to one anther in a mass and afterwards to separate them by mechanical means such as passing them through a sieve. This method has been pursued as I learn from Mr. Stranahan, at the U. S. hatchery at Put-in-Bay, Ohio.

A trial showed that the eggs when separated are distorted by the mutual pressure. Some are elongated, others are flattened and scarcely any are spherical. About ten to fifteen per cent more of the eggs are injured mechanically than by the process next to be described.

3. It might be possible to add to the water some substance that should get between the eggs and prevent their touching one another. It was believed that the reason that the eggs did not adhere in milted water is that the heads of the spermatozoa attach themselves to the surfaces of the eggs and getting thus between them act like so many little buffers. The eggs are thus so thickly studded with these little bodies that they cannot touch one another and do not therefore adhere.

The alkalinity of the milt prevents the eggs from filling and it was thought that perhaps some other finely divided substance not alkaline might be placed in the water to take the place of the milt. Trials were made of egg yolk. After fertilizing the eggs they were placed in water containing egg yolk in a finely divided condition. The eggs did not adhere but they did not develop. Fine clay mixed with water was also found to be useless. The egg yolk probably failed through some chemical action on the eggs or milt. It seemed likely that the failure of the clay was to be attributed to the fact that the fine hard particles cut their way into the outer egg-membrane and became so deeply imbedded in it that the eggs were able to touch one another and adhere.

Corn starch was then tried. About one volume of dry corn starch was added to twenty volumes of water. The eggs were fertilized in the usual way and were immediately (after two or three minutes) poured into the starch water. Another lot of eggs was then fertilized and added to the starch water and the work was continued until the pail containing the starch water had been half filled. It was found that the eggs settled to the bottom of the pail and became thickly coated with the starch, which prevented their adhering to one another. The eggs could thus lie quietly and the evil effects of agitation were avoided. At the same time by being placed in the starch water they were brought suddenly into a large quantity of fresh water and the milt was thus washed off almost immediately so that the water on the eggs was not alkaline. The starch in the pails settles slowly so that after ten minutes there is much starch in the water at the bottom of the pail and but little in that at the top. The top water may then be poured off and fresh water added, and the eggs and starch brought into contact with the fresh water by a few twisting and swinging movements of the pail. As the starch again settles the water may be again changed so that without using fresh starch there is a changing of the water every ten minutes (if deemed necessary). The eggs may lie in the starch water for four hours or longer, but at the end of two hours, they were usually washed up to free them from starch. They were found well filled and developing normally, they had not adhered to one another and did not adhere when transferred to fresh water. The starch appeared to have no other effect on the eggs than to keep them apart.

Counts of eggs treated in this way showed between fifteen and thirty per cent more of fertilized eggs than were obtained by the usual method.

Here are two examples taken from a considerable number of experi-

ments. In each case a batch of eggs was fertilized and then divided into two lots, one lot was then treated in the usual way while the other was treated by the starch method.

TRIAL ONE.

	By the usual method.		By use of starch.	
Segmenting	112	63%	153	99%
Injured	2	1%	2	1%
Not segmenting	63	36%	0	0%
Total	177	100%	155	100%

TRIAL TWO.

	By the use of starch.		By the usual method.	
Segmenting	81	30%	39	15%
Injured	18	6%	33	12%
Not segmenting	176	64%	190	73%
Total	275	100%	262	100%

The first trial shows a gain of 36% (almost double the average) and the second a gain of 15% by the starch method. Three other trials gave each a gain of 15% and a fourth trial gave a gain of 23%. By the usual method is meant that the eggs were kept in motion and the milt washed off rather slowly. A trial of the method of allowing the eggs to adhere and afterward separating them showed a gain of about 5% over the usual method, but a disadvantage of 10%-15% as compared with the starch method.

Thus out of a considerable number of experiments there is an average gain of about 20% by the use of the starch method; so that the method certainly merits a trial on a commercial scale. It is always possible to handle a small number of eggs, as a few thousands, in such a way as to secure a very large percentage of fertilized and uninjured eggs. The extreme care in manipulation which is necessary to accomplish this cannot be used where the number of eggs is so greatly increased and where the conditions for working are so unfavorable, as is usual in commercial practice. By the use of starch, eggs may be handled with very much less trouble than by the methods now in vogue, so that the method may be of value, even if it is found in practice to produce no increase in the number of eggs saved.

In any trial made to test the commercial value of this method the eggs operated upon should be divided into two lots, one of which should be treated by starch and the other by the ordinary method. The two lots should receive identical subsequent treatment and should be finally compared.

One such trial has been made by Mr. Dwight Lidell of the State Fish Commission at the suggestion of the writer. About three and a half million eggs were used. The starch method, used on nearly half the eggs, showed an advantage of about seven per cent. The record does not show whether the two lots of eggs were taken on the same day or from the same catch of fish or whether their subsequent treatment was the same.

The matter needs to be tested by more extended trials under proper control.

EARLY HISTORY OF THE FISHERIES ON THE GREAT LAKES.

BY HERSCHEL WHITAKER.

Stretching away to the northward from the low Laurentian hills of New York to the trap-rock cliffs of Minnesota, for a distance of sixteen hundred miles, in a hydrographic basin embracing an area of one hundred and seventy-five thousand square miles, lie the Great Lakes of the northwest, the largest bodies of fresh water upon the globe. Upon their bosoms float vast fleets which carry the rich products of prairie, forest and mine, while from their depths the fisherman gathers the rich bounties that nature has provided for the sustenance of man.

The vessels which constantly pass and repass are not freighted with ores from the mines of Golconda nor with spices from far Cathay, but carry lumber from Saginaw, iron from Escanaba, copper from Hancock, grain from Duluth, provisions from Chicago, and cereals from the vast prairie lands of the Dakotas.

Since the early days of the French occupation of the northwest, when the lilies of France waved over all the territory lying north of the St. Lawrence and Ohio and west of the Alleghanies, these lakes have been the great highway of intercommunication between the east and west. The Jesuit missionary filled with holy zeal departed from Montreal, the seat of French power in America, in his bark canoe, manned by his Indian converts, for the trackless wilds of the far west, to raise the cross and establish his feeble mission among savage tribes.

Following him came the fur trader with his canoe and *courrier du bois*, who day after day traversed these lakes and their connecting rivers to reach some specially designated place where he might exchange his tawdry gewgaws, beads and cheap merchandise with the Indian for the valuable skins of beaver and otter.

The cavalier, explorer and adventurer traveled over their trackless wastes of water, enduring hardship and fatigue, living upon the bounties of nature, pushing his way to what he hoped would be a discovery of a path to the Indies, fortune and fame. Each of these in his own way has left testimony of the bountiful way in which nature has stocked these waters with desirable food, and the belief of all concurred that there was an unfailing supply for man for all time, to be had for the taking.

The habits of the tribes bordering these lakes, whose main reliance for food was upon the fishes that inhabited them, had caused them to resort to certain favorable localities upon the lakes at the proper season of the

year to take fish for present wants and for future use. In time these points became their chief dwelling places for the greater portion of the year, and with the advent of the fur trader they became the principal places of barter.

Such localities as the Straits of Mackinaw, Sault Ste. Marie, Green Bay, Chequamegon, Detroit and Chicago became thus early known, and the history of these places as told by the early traveler shows that nature seemed to have lavished her bounties upon aboriginal man in the stocking of her waters with the most edible of fishes to provide for his wants.

Let us call a few of the earlier voyagers to give their testimony upon the abundance of fish in these waters.

Hennepin says in his Travels in 1675: "There is a very abundant fishery of several kinds of fish at the mouth of the Niagara river, among which is the whitefish, admirably good, with which you might supply one of the best cities of Europe.

"At Mackinaw the Griffin lay in the harbor amid one hundred and twenty canoes going and coming from taking the whitefish which the Indians catch in nets in from fifteen to twenty fathoms of water and without which they could not subsist at all.

"At the Sault the Indians subsist by hunting stags, moose or elk and some beaver, and by the whitefish which is very good and is found in great abundance, but this fish is very difficult to take to all but these Indians, who are trained to it from childhood."

He says, on his return from his first voyage up the lakes, and after the loss of the Griffin: "On reaching Lake Conti (Lake Erie) near the mouth of the Detroit river, the soldiers who were in canoes killed with their swords and with their axes more than thirty sturgeons which came to spawn on the banks of the lake."

Charlevoix, in his voyage to North America, 1721, in speaking of Lake St. Clair, the smallest lake of the chain which lies between Lake Erie and Lake Huron: "The islands in the river seemed placed on purpose for the pleasure of the prospect, and the river and the lake abound in fish. Were it not for the Hurons at Detroit the other tribes of Indians would starve. This is in the flat lands thereabout which would furnish them sufficient subsistence though it were cultivated ever so little, but they can subsist upon the fish of the river which are plentiful. We entered the Lake Huron where we soon had the pleasure of fishing for sturgeon."

Speaking of Lake Superior, he said: "The Indians from gratitude for the plentiful fish with which this lake supplies them, and from the respect which its vast extent inspires, have made a sort of divinity of it." Speaking of Michillimackinas, he says: "The Indians live entirely by fishing, and there is perhaps no place in the world where they are in greater plenty. The most common sort of fish in the three lakes which discharge themselves into these straits are the herring, the carp, the goldfish, the pike, the sturgeon, the attikumaig or whitefish, and especially the trout. There are three sorts of these taken, among which is one of monstrous size, and in so great quantities that the Indian with his spear will strike to the number of fifty sometimes in the space of three hours, but the most famous of all is the whitefish, and nothing of the fish kind can exceed it."

In speaking of his trip from Mackinaw to Green Bay, he says: "We coasted the north shore of the Straits of Mackinaw and finally came to the Manistique river, which is a beautiful stream abounding in fish, especially the sturgeon."

Captain John Carver, of the Provincial troops of America, in his three years' travels throughout the interior parts of North America, says: "Lake Superior abounds with a variety of fish. The principal and best are the trout and sturgeon, which may be caught at all times in the season in the greatest abundance. The trout in general weigh about twelve pounds, but some are caught that exceed fifty. Besides this a species of whitefish is taken in great quantities here that resemble a shad in their shape, but they are rather thicker and less bony. They are about four pounds each in weight and are of a delicious taste. The best way of catching this fish is with a net, but the trout might be taken at all times with the hook. There are likewise many sorts of smaller fish in great plenty here, and which may be taken with ease. Among these is a sort resembling the herring that are generally made use of as a bait for the trout."

Speaking of the falls of Ste. Marie, he says: "Nature has formed a most commodious station for catching the fish which are to be found here in immense quantities. Persons standing on the rocks that are adjacent to it may take with dipping nets about the months of September and October, the whitefish before mentioned at that season, together with several other species. They crowd up to this spot in such amazing shoals that enough may be taken to supply, when properly cured, those inhabitants throughout the year. The fish of Lake Huron are much the same as those in Lake Superior."

Carver arrived at Mackinaw at the beginning of November, 1767, after having been to the Mississippi river and up that stream as far as the Falls of St. Anthony. He says: "We passed the winter very pleasantly at the Straits of Mackinaw. One of their amusements at this time was to fish through the ice for trout. Though the straits were covered with ice we found means to make holes through it, and letting down a strong line fifteen yards in length to which we fixed three or four hooks bated with the small fish before described, we frequently caught two at a time of forty pounds weight each, but the common size is from ten to twenty pounds. The method of preserving them during the three months the winter generally lasts, is by hanging them up in the air, and in one night they will be frozen so hard that they will keep as well as though they were cured by salt."

This may properly be considered as the first authentic notice of preserving fish by the freezing process, and while it is crude it still is as effective as the work now done by the immense freezers found in almost every important town on the lakes.

George Heriot, deputy postmaster general of British North America, in his book of travels, published in 1807, says of Mackinaw, that the Indians of that locality "catch herring, whitefish and trout, the trout being from four to five feet in length, some of which are seventy pounds in weight. This fish is bred in Lake Michigan and is known by the name of Mackinaw trout, and affords a most delicious food." On Green bay he says: "There is a village composed of natives at the mouth of this river who employ themselves in fishing."

At the Sault Ste. Marie, "At the bottom of the rapids and among their billows which foam with ceaseless impetuousity, innumerable quantities of excellent fish may be taken from the spring until winter. The species which is found in great abundance is denominated by the savages attikumaig or whitefish. The Mackinaw trout and pickerel are likewise caught

here. These afford a principle means of subsistence to a number of the native tribes."

He also speaks of the method of taking the whitefish at this place in the rapids at the foot of the falls, which, singularly enough, is followed by the Indians to this day, and from its peculiarity deserves special mention. I give his own words:

"No small degree of address as well as strength is employed by these savages in catching these fish. They stand in an erect attitude in a birch canoe, and even amid the billows they push with force to the bottom of the waters a long pole, at the end of which is fixed a hoop with a net in the form of a bag, into which the fish is constrained to enter. They watch it with the eye when it glides among the rocks, quickly ensnaring it and dragging it into the canoe. In conducting this fishing much practice is required, as an inexperienced person may, by the efforts which he is obliged to make, overset the canoe and inevitably perish. The convenience of having fish in such abundance attracts to this situation during the summer several neighboring tribes, who are all of an erratic disposition and too indolent for the toils of husbandry. They therefore support themselves by the chase in winter and by fishing in the summer.

"The Otter nation inhabit the rocky caverns on Lake Huron, where they are sheltered by a labyrinth of islands and capes. They subsist on Indian corn and fish and the proceeds of the chase. While the women and children collect berries the men are occupied in darting sturgeon."

Mr. Henry R. Schoolcraft from the time of the establishment of the military post at Sault Ste. Marie, was the United States Indian agent at this point. He was a man of culture and of literary ability, and one of the most prolific contributors to the literature concerning the habits, characteristics and language of the North American Indians. He says of the whitefish at the Sault in 1820:

"No place in America has been so justly celebrated as a locality for taking this really fine and delicate fish as St. Marie's Falls. This fish resorts here in great numbers, and is in season after the autumnal equinox, and continues so until the ice begins to run. It is worthy the attention of ichthyologists. It is a remarkable but not singular fact in its natural history, that it is perpetually found in the attitude of ascending at these falls. It is taken only in the swift water at the foot of the last leap or descent. Into this swift water the Indians push their canoes. It requires great skill and dexterity for this. The fishing canoe is of small size and is steered by the man in the stern. The fisherman takes his stand in the bow, sometimes bestriding the vessel, having a scap net in his hand. This net is made of strong twine, open at the top like an entomologist's. When the canoe has been run into the uppermost rapids and a school of fish is seen below or alongside, he dextrously puts down his net and having swooped upon a number of fish, instantly reverses it in the water, whips it up and discharges its contents into the canoe. This he repeats until the canoe is loaded, when he shoots out of the tail of the rapids and makes for the shore. The fish will average three pounds, but individuals are sometimes taken two or three times that weight. It is a great resource of the Indians and of the French, and of the poor generally at these falls, who eat it with never-ceasing appetite. It is also a standing dish with all."

Listen to his tribute to the edible character of the whitefish:

All friends to good living by tureen or dish,
Concur in exalting this prince of a fish,
So fine in a platter, so tempting a fry,
So rich in a gridiron, so sweet in a pie,
That even before it the salmon must fail,
And that luscious *bonne bouche* of the land beaver's tail.
* * * * * * *
'Tis a morsel alike for the gourmand or faster,
While white as a tablet of pure alabaster,
Its beauty or flavor no person can doubt
When seen in the water or tasted without,
And all the dispute that opinion ere makes,
Of this king of lake fishes, this "deer of the lakes,"
Regard not its choiceness to ponder or sup,
But the best mode of dressing and serving it up.

Sheldon, Disturnell, Strickland, Kohl, Hubbard and others all unite in saying that nature here seems to have lavished her bounties with no niggardly hand, so profusely are these lakes stocked with fish.

From the time of the discovery of the lakes down to the time of the establishment of the Hudson Bay Fur Company, these inexhaustible supplies were drawn upon only for the subsistence of the Indian tribes and the voyagers, but gradually they became, to a small extent, an article of commerce, the surplus being salted and sold in somewhat inconsiderable quantities. During all this time the northwestern territory was looked upon as a source from which valuable furs could be obtained, and but little attention was paid to the fisheries of the great lakes beyond what the immediate wants of those who lived upon them or near them demanded.

Little is known at the early time of which I speak with reference to the fisheries of Lake Erie, because of its situation it was but little frequented by the explorers and fur-traders. Good reason existed for this condition of affairs. The bloodthirsty and cruel Iroquois, the most adventurous and warlike Indian tribe which ever inhabited the continent, held undisputed possession of all that wilderness lying about Lakes Ontario and Erie and adjacent to the Niagara river, which was a key of approach to the latter lake.

The rivalry between the Dutch fur-traders of New York and those of the French was exceedingly intense in their attempts to control the fur trade of the northwest. The Iroquois were incited by the Dutch to throw every obstacle possible in the way of encroaching advances by the French traders and colonists. For many years the Iroquois, who by reason of their situation acted as intermediaries between the further western tribes of Indians, controlling in their own interests the fur trade between the Dutch and these tribes, fiercely resented all attempts at interference in this trade by the French. As a result of their attitude the great waterway communication between Montreal, the seat of the French fur trade, and the great northwestern lakes was closed by the Iroquois, and communication with the upper lakes was made by way of the Ottawa and French rivers into Georgian bay and from thence into lakes Huron, Michigan and Superior.

Meager, however, as the information is that we have concerning the condition of the fisheries on Lake Erie at this early period, such information as we have shows beyond question that fish were exceedingly plentiful, especially at the Put-in-Bay islands and Sandusky bay. Dr. McCallum of Dunville, Ontario, at a meeting of the International Fish Conference, held at Hamilton last winter, exhibited to the meeting two crude shellfish

hooks which were found on Point au Pelee, in the Province of Ontario on the north shore of Lake Erie. These hooks were presumably made from the shell of the fresh water mussel. In appearance they resemble the rude hooks employed for taking fish by the Esquimaux and other aboriginal types. The shank and the point were in two separate pieces, having holes drilled through them by which they could be attached to each other with thongs, the hook itself being barbless. Their form and construction indicated plainly that if the aboriginal man was compelled to sustain life by means of fish taken with such an implement, the fish must have been exceedingly plentiful in this lake. Facts at hand would seem to indicate that Lake Erie was in these early days bountifully stocked with fish, and although it has been fished constantly for a very long period, it still yields immense quantities of valuable commercial fish.

Blois speaking of the condition of the fisheries as early as 1835, in his "Gazetteer of Michigan," says: "Their quantities are surprising, and apparently so inexhaustible as to warrant the belief that were a population of millions to inhabit the lake shores they would furnish ample supplies of this article of food without any sensible diminution."

Looking at the matter from that period of time the writer was unquestionably warranted in his assumption. But Blois could not have apprehended at that time that the census of 1890 would show that in the six states surrounding the great lakes there was a population constituting more than one-sixth of the entire population of the country. Neither conld he anticipate that the methods of preserving fish would, within thirty years from the date of this writing, make it not only possible but profitable for fishermen to follow their calling almost continuously during the entire year.

Michigan statistics show that in 1830 the quantity of fish marketed in the State amounted to 8,000 barrels valued at $40,000.

In 1836 the whole numbers of barrels taken amounted to 11,400.

In 1837, to 13,500 barrels of the value of $125,800. Of this quantity one-fourth was consumed in the State and the rest was shipped to Ohio, New York and Pennsylvania.

It will be observed that the reports of the catch and value of the commercial fish upon the great lakes are somewhat meager and desultory. The report of the Detroit board of trade for 1857 shows that there were between 80,000 and 100,000 barrels of fish taken in that year, valued at $640,000.

In 1885 the reports gathered by the Michigan State Board of Fish Commissioners show that the value of the commercial fish taken in the State was about $1,500,000 at wholesale price.

In considering such statistics as we have, we must take into account the uncertainty and unreliability that must necessarily prevail in their collection because of the want of thoroughness and completeness with which the work was done in the earlier years. So, too, we must consider in comparing one year with another the varying conditions of seasons, which is a potent factor. Severe storms may prevail one year, while the next year may be an exceedingly favorable one, and, therefore, their reliability is much impaired and the basis upon which we must make comparison is at best unsatisfactory.

CAUSES OF DECAY.

Until about the year 1852 the fishing industry on the lakes was prosecuted almost entirely with gill-nets. Since then the gill-net fishing has continually increased until now the length of the gill-nets fished in Michigan waters alone, according to the last reliable statistics within our reach, amounts to 1,725 miles.

About the year 1850 the pound or trap-net was introduced into the great lakes. Its use conclusively shows that it has been one of the most destructive of fish devices, and is responsible for the great decay of the fisheries which has been observable during the last twenty years.

Concerning the introduction of the pound-net into the great lakes, I am indebted to Mr. L. Anthony of Sandusky, O., for the following facts:

"Pound-net fishing was first introduced by Messrs. Spencer and Courtland, two Connecticut men, at Sandusky, O., in the year 1850. The fishing with these nets was at first done in shoal water in the bays and rivers in a depth of about 10 or 12 feet."

In 1852 Mr. L. Anthony of Sandusky, in the fall of that year began fishing with small bay nets, which was the first attempt. This fishing was done at Locust Point, between Toledo, O., and Port Clinton, Ottawa county in the same state, in a depth of nine feet of water. The fish were plentiful and the catch was remarkably large. He salted fifteen hundred half barrels of whitefish during this season, besides selling large quantities to the farmers, who came to the fisheries from long distances.

In the fall of 1854, Mr. Spencer, the gentleman formerly alluded to, together with other parties, including Mr. Anthony, conceived the idea that this plan of fishing could be successfully done in the deeper waters of the lakes. The first attempt was made by Mr. Anthony at deep water pound-net fishing, in the spring of 1855, at Kelly's island and Put-in-Bay, in Lake Erie, Ohio, with marked success.

In the year 1854 he did his first pound-net fishing in Lake Huron at North Thunder bay, fishing in 33 feet of water; fish were caught here in large quantities. There has also been some small fishing done near Lexington, Mich., which was not successful.

In the year 1856 Charles Ruggles and Capt. James Bennett fished with deep water pound-nets in Hammond's bay, on the south shore of Lake Huron, and also on the north shore of Lake Michigan. At that time this was the largest and most successful fishery in the whole country. At the Thunder bay fishery on Lake Huron, Mr. Anthony caught in one net in twenty-four hours, four hundred half barrels of whitefish. There were not one hundred pounds of other varieties caught on this occasion.

In 1865, he commenced fishing with deep water pound-nets at the Apostle island, Madeline island, Presque isle and Sand island in Ashland bay, off Bayfield Point, in Lake Superior, and these fisheries resulted in a profitable investment.

From this date on the pound-net fishing increased beyond all conception. It is not infrequently the case that pound-nets are set in gangs reaching out from the shore a distance of three or four or more miles, and the destruction of fish by this method of fishing is immense. Unquestionably the fish so taken are superior to fish taken by the gill-nets because they are preserved alive until the nets are raised, but it takes everything, great and small.

No fishculturist should condemn the taking of fish if the fishing were done with judgment and with a due regard for the future.

The iniquitous feature of the business is that the cupidity of the fisherman overcomes his better judgment, and he takes from the water large numbers of small and immature fish that are of little or no value as merchantable fish. The result of this system of fishing is most destructive, tons upon tons of fish being thus taken which have never spawned, whereas if they were permitted to remain in the water to reproduce their kind, artificial methods would be greatly aided.

About the year 1868, Mr. William Davis of Detroit, patented a freezing apparatus for the preservation of fish. In that year about sixty tons were frozen in Detroit, and seventy-five tons in Toledo. This method of preserving fish was not very kindly received at first, but gradually grew in favor. Previous to this time, during favorable seasons, large quantities of fish were taken over and above the needs of present consumption, and the only means of preserving them was by the salting process, which considerably reduced their value. Gradually the freezing process grew in favor, and it was found by experience that fish might be frozen and held in that condition for any length of time. The result has been that in almost every important town upon the lakes which is the seat of a fishing industry, there are today one or more freezers with varying capacities, most of which are exceedingly large. Their erection has given a great impetus to the fishing industry. While formerly the lake fishing was prosecuted mainly in the spawning season, the methods of fishing have so changed by reason of the opportunity offered by the freezer system of holding the fish for any length of time that now and for a number of years past fishing has been carried on in nearly every month of the year, and is only interfered with by the rigor of the season when nature closes the waters for perhaps a month or so.

Reliable statistics furnished show that the following quantities of fish were frozen from 1869 to 1884: In 1869, 400 tons; 1871, 600 tons; in 1872, 600 tons; in 1873, 700 tons; in 1874, 600 tons; in 1875, 800 tons; in 1876, 1,100 tons; in 1877, 1,200 tons; in 1878, 900 tons; in 1879, 1,100 tons; in 1880, 700 tons; in 1881, 1,100 tons; in 1882, 1,300 tons; in 1883, 1,450 tons; in 1884, 1,600 tons.

No information is at hand for the seven years from 1884 to 1892, during which years it is fair to be presumed from the general knowledge we have on the subject, these amounts were very largely increased.

The average number of tons per year for the fifteen years amounts to 1,000 tons. Averaging these fish at 2½ pounds weight apiece, the number of fish caught on an average for each year and frozen would be 800,000, and for the entire period of fifteen years it would amount to 12,000,000 fish. This takes into consideration only the fish that were frozen, and my opinion is, that if there is any error in the above figures, they are much below the actual amount. But by far the greater quantity of fish taken are sent to market, iced, fresh, but not frozen. I believe it is within reason to say that the frozen fish will not represent more than one-fifth of the total quantity taken.

When we consider this large number of fish which are being constantly taken from these lakes, we can better appreciate the serious inroads which are being made upon the supply; and when we add to this the wanton destruction of millions of small and immature fish taken that are never given an opportunity to spawn, and when we further consider the large

number of gravid females, the roe of which is lost by this capture, we can begin to appreciate the problem that is set before fishculturists to restore this great loss.

MEANS OF ARREST OF WASTE AND RESTORATION.

If the wealth of the waters of the great lakes is to be maintained, nothing can be clearer than that this great waste, which has been going on for more than a hundred years and is increasing, must be arrested. There are two methods by which this may be effected:

1. By a liberal and lavish stocking of the waters.
2. By the enforcement of just protective laws preventing the taking and marketing of unmerchantable, young and immature fish.

As to the first point each state must act for itself in protecting its own interests in the fisheries. Weak and erratic efforts made now and then to make good the loss by the planting of a few million fish will not do. With the means at hand and with the information we now have as to fishculture, and with the small outlay of money necessary to carry on the work of artificial propagation, each State should see for itself that every female fish taken during the spawning season in its waters shall have her eggs taken from her, fecundated, and after being hatched, properly planted; there is no good reason why this should not be done. and if the states whose interests are involved will take immediate steps to carry out this line of policy, they will have taken a step in the proper direction for the maintenance of their fisheries.

As to protective laws, let me say this: No laws should be passed which should rob the fisherman of the right to follow his calling within legitimate means. If our work means anything it means that we are engaged in an undertaking which, if properly conducted, will result in a direct benefit to the fishermen and incidentally in great benefit to the people at large in the maintenance of a cheap and wholesome food. With this understanding of the conditions, fishermen should be willing to submit to such just and necessary laws as may be required to prevent destruction of young fish which are of no special value for their purposes, and the destruction of which means the ultimate decadence and extinction of their means of livelihood. So far as uniformity in laws can be secured regulating the fishing in the different states, they should be made uniform, but experience seems to indicate that the fault lies not in the number or effectiveness of statutes, but in the inadequacy of the means which have been used to enforce them.

Most of these laws are inherently defective because of the attempt to build up a warden system by counties, allowing the compensation of wardens to be fixed by the boards of supervisors, who, as a rule, will grant no compensation, or one which is grossly inadequate, which results in making the warden system of no effect. New York has without doubt the best warden law of any state in the union, because the pay of her wardens is sure and fixed.

The ideal law would be one giving authority to the board of commissioners of each state to appoint a chief warden with such deputies as he might require for a proper enforcement of the laws, whose compensation should be sufficient to secure the services of good men who should be paid by the state. The state might be districted, but in that event each warden could exercise the functions of his office in some district other than

the one in wich he resides, thereby removing him from local influence in the administration of his duty.

The states should make and enforce their own laws. No other power can do it so effectually and well. Their legislatures are familiar with the necessities of their states, are quick to respond to the wants of different localities, and by frequent contact with their constituencies know their wants.

If a general awakening of the lake states can be had as to the necessity of proper action to maintain their fisheries as above suggested, there is no reason why the great food supply furnished by these waters may not be maintained at least in their present value, with a hope of future increase.

STATE CONTROL OF STATE FISHERIES.

BY HOYT POST.

At the last meeting of this society, just at the close of the session, there was hastily adopted a resolution, prefaced by four whereases, upon a subject matter which has since attracted considerable attention in certain quarters.

This resolution related to petitioning congress to assume the work of protection and propagation of fish in the waters of the great lakes, and the whereases suggested taking this work out of the hands of the several states which are now conducting it, it is said, "with slight probability of ever arriving at a harmony of action," and placing it in the control of the federal government, which, it is stated, could, "with its great scientific, mechanical, and financial resources, its power to make agreements with Canada, and its ability to enact and enforce regulations," "undertake this work with far greater results" than have heretofore been attained. This resolution was a source of surprise to several of the state commissions, and especially to that of Michigan, which took prompt action upon it.

In October, 1891, a meeting of the fish commissioners of New York, Pennsylvania and Ontario, with representatives of the United States commission, and some others especially interested in the subject, was held at Fifth Avenue Hotel in the city of New York, the object of which was stated to be the "protection, preservation and propagation of food fish in the great lakes."

This meeting appointed a special committee which met at the chamber of commerce in Rochester, New York, on November 10, 1891, at which meeting a series of resolutions were adopted; which were afterwards reported to the final meeting at Hamilton, Ontario, December 8, 1891, and there finally adopted. The portion of the resolutions which pertains to the matter under consideration in this article is as follows, viz.:

"*Resolved*, That this body disregards with disfavor any movement looking towards the turning over to the United States government of the work of the state commissions in propagating and planting commercial fish in the great lakes.

"That the jurisdiction over the State fisheries belongs naturally to the adjoining States whose interest in their success is paramount to that of the United States as a whole; and

"That there is an abundant field for the concurrent action of the bordering states and of the general government, and anything which would

detract from the state's interest in this matter will be detrimental to the end aimed at, of restocking the waters of the great lakes.

"And we recommend a course which will encourage and stimulate greater interest and larger expenditures in this great work by the several bordering states, and at the same time increased interest in the subject by the United States fish commission;

"*Resolved, further*, That this body earnestly approves of the action of congress in making an appropriation for the establishment of a hatching station on or near the St. Lawrence river for the propagation of whitefish and other commercial fish; and of the purpose of the United States fish commissioner to carry out the provisions of that appropriation; and we see nothing in this movement that can in any degree interfere with the jurisdiction of the states in the premises, or to affect in any way unfavorably the work of the states in the protection, multiplication and distribution of valuable food fishes."

Afterwards the same subject was again brought prominently into view by the introduction in congress at its present session of the Lapham bill, so called (H. R. 5030), entitled "A bill to regulate the fisheries and for other purposes." This bill related on its face to the taking of menhaden and mackerel with purse seines along the sea coasts and shores of the United States and adjacent islands and in the bays, harbors and estuaries thereof, but it contained an insinuating reference to the great lakes. Its evident aim was to extend the jurisdiction of the federal government over fisheries in waters which are within the exclusive jurisdiction of the states. This bill received such energetic opposition from the states of Maine and Massachusetts, aided by the board of fish commissioners of Michigan and other states, that the committee on merchant marine and fisheries, to whom it had been referred, decided by a vote of seven to six that it was unconstitutional.

Thereupon the promoters of said bill caused a new bill to be introduced which was known as H. R. 7553 and which was identical in principle with the former one. This bill was afterwards unanimously decided to be unconstitutional.

The plan of interesting congress and the federal government in the matter of federal control of the protection of the commercial fisheries, has attracted considerable attention at various times for several years. From a superficial survey of the subject it seems to those not thoroughly informed, very desirable because of its tendency towards uniform rules and laws governing all the fisheries. Consequently the matter has been often considered, and while at first blush it appears very promising yet the conclusion uniformly reached after careful inquiry is that it is impracticable because congress has no jurisdiction under the constitution over the fisheries in waters which are within the boundaries of the states. A thoughtful consideration of the whole subject, however, convinces most persons that it is also undesirable as well as unconstitutional.

October 17 and 18, 1883, an interstate convention of fish commissioners was held at Detroit, and at the request of the Michigan board, Otto Kirchner, who was then Attorney General of the State, examined the authorities and announced to the convention his conclusion that it was not within the powers of the federal government to assume control of the fisheries in waters within the state boundaries.

Within the present month John Z. Rogers publishes over his own signa-

ture in *Harper's Weekly* of May 14, 1892, an article in which he forcibly depicts the rapid decrease in the catch of codfish, mackerel and lobsters within the past ten years, and shows that the depletion caused by the destructive methods of fishing has resulted in the ruination of the business, and concludes, as so many others have, that the remedy lies with congress passing laws for the protection of the fisheries.

In view of the precedents upon the subject and the repeated decisions of the courts that congress has no authority over the matter, it is surprising that people of intelligence should so persistently fall into this error. The right of the state over the fisheries in waters within its borders has been the subject of frequent decisions of the courts of this country, and those decisions have been uniform and without conflict or variation in favor of the exclusive jurisdiction of the state authorities. These decisions are not confined to the state tribunals, but the most potent and forcible of them were enunciated by the supreme court of the United States. This unbroken line of decisions commences as early as 1823, with the case of *Corfield v. Coryell*, 4 Wash. C. C., 371, and comes down to the recent case of *Manchester v. Massachusetts*, 139 U. S., 258, and embraces elaborate and exhaustive opinions of such eminent jurists as Washington, Story, Marshall, Curtis, Waite, Bradley and Shaw.

The right of the state to control its own fisheries is sustained by the courts as a property right, and as an incident to the ownership of the soil beneath the waters, which has never been ceded or delegated to the United States, and it is held that the state may exclude citizens of other states from using said fisheries and may regulate their use at its discretion.

It has been sought again and again to uphold the right of federal supervision of the fisheries in navigable waters under the grant of power to regulate commerce; but this has been uniformly and repeatedly overruled by the courts. The possession of a United States "fishing license" has been set up as a defense for the violation of state regulations; but it has never been sustained. Legislation by congress has been urged on the ground that citizens of each state should have equal rights with the citizens of the state in which the waters were, of fishing for floating fish in any navigable waters, but the power of congress over the matter has been uniformly questioned and ultimately denied. Such a bill was introduced at the first session of the forty-ninth congress, and was numbered H. R. 4690. It was referred to the committee on judiciary and was reported adversely. The report was drawn by that able constitutional lawyer, J. Randolph Tucker of Virginia. The conclusion of that report is, "that the navigable waters within each state belong to it, subject to the paramount right of navigation, for the benefit of its own people, and it has the right to secure the exclusive right of fishing in them to its own citizens by virtue of their common property in said waters, and that the citizens of other states have no constitutional right, nor can congress confer any, to participate in fishing in them." This right of the state is treated as a property right and not a mere privilege or benefit of citizenship.

It is worse than useless then to look to congress or to invoke the authority of the federal government, to protect or control or to interfere in any way with the regulation of the fisheries within the states. It has no power, no authority, over them, and cannot possibly acquire any short of an amendment to the constitution, which could never be obtained. It is a state matter, and the state alone must be looked to for its proper administration. The sooner this becomes generally known and recognized

the sooner will people cease chasing this *ignis fatuus* and direct their undivided attention to the proper authorities to correct the evils complained of, and by placing the duty and responsibility where it naturally and of right belongs, will more surely accomplish the desired results.

Federal control of the commercial fisheries is not only unconstitutional and therefore impossible, and incapable of enforcement; but it is eminently undesirable and unnecessary.

To properly frame the laws necessary for the regulation of fisheries and the protection of the fish from indiscriminate and exhaustive slaughter, requires intimate local knowledge of the innumerable differences of temperature, climate, fish food and habits, of varying spawning periods and the feeding and spawning grounds, as well as the various and constantly changing methods and devices of the law breaker. These laws must have the moral support of local public opinion; they must be wisely drawn and promptly and discreetly enforced; they must admit of proper discrimination to avoid hardship; and any mistakes or defects be capable of prompt remedy, to adapt the penalties to the varying circumstances. Defects in the fisheries laws to adapt them to the widely varying surroundings of particular localities will be more suitably remedied by a speedy appeal to the state legislature, than by recourse to a distant and overburdened congress. The speedy and continuous vindication of the law against the repeated assaults by reckless and unprincipled fishermen, who are spurred on by the hope of great present profits, can far better be entrusted to numerous and easily accessible local tribunals than to distant and leisurely federal courts. While uniformity of rules and regulations, which seems to many the highest and almost the sole desideratum, undoubtedly has its merits, it is manifest that a discriminating and readily adapted legislation, vigorously enforced by local officers, prompt to respond to public interests, will be more effective than general ironclad regulations made by a national fish commission and enforced by United States officials, practically irresponsible to local sentiment. Practical experience has demonstrated that anything in the nature of police regulation is, in the long run, better left to the control of local authorities, administered by local officers before local tribunals. Local self-government has long been recognized as the strongest bulwark of popular sovereignty and the surest guarantee of our free institutions.

In strange contrast to the persistent advocacy here of federal control and supervision of the fisheries, is the course of our neighbors over the border. In Canada a determined effort is now being made to have the control of the local fisheries taken out of the hands of the dominion and given over to the provinces.

In conclusion we commend the sentiment expressed and the course recommended in the resolutions adopted at the Hamilton meeting, quoted above, and which were formulated by the Michigan commission and spread upon its records soon after the adjournment of the last meeting of this society, as a refutation on the part of the members of that commission of the action of this society in passing the resolution mentioned at the beginning of this article.

FRY VS. FINGERLINGS.

BY HERSCHEL WHITAKER.

Much has been said and more has been written in the last two years regarding the desirability of planting fingerling trout as against the planting of fry, as a surer and more effective means of stocking the streams of the country. The idea, like all new ones, has found ready advocates who have taken up the cry, until it has come to be believed that there is real foundation for the claim, and that it is a mistake to pursue further efforts along the line of fry planting. To those who have had experience in fish-culture and are familiar with the results of the work done for the past ten or fifteen years, I think the claim of the fingerling advocates does not appeal very strongly, but with the unthinking ones it has met with more favor than it deserves or would have received upon a full and thorough investigation.

In considering this question we cannot fly in the face of past great success as the result of stocking waters with fry, neither can we disregard the fact that if plants are made of fish at a fry age we have attained the maximum of output at a minimum of cost. That the cost of raising fish to the fry age is cheap no one can deny, and that it has been eminently successful is beyond refutation. This being admitted let us recall for a moment past experience and see what has been done and what has resulted from fry plants.

No stronger argument can perhaps be presented on this point than the remarkable success attending the restocking of the shad rivers of the Atlantic coast, which have been restored from a point of great decay to a condition where the fishing is profitable. This is emphatically the case with some of our salmon rivers, and noticeably the Penobscot, where the run of the salmon had almost entirely failed. The papers devoted to angling and fishing interests have shown that for the last three or four years, or perhaps more, the salmon are beginning to return to this river, and the spring accounts of the fishing at Bangor, made daily, show that the stocking has been a success beyond all question, fish being taken as high as thirty pounds weight. The salmon and shad being anadramous in habit, the fry have had to run the gauntlet not only of their natural enemies in the streams which they frequent but of the countless enemies of the ocean where they remain for the greater part of the year. Notwithstanding this condition of things the results speak for themselves.

So much as a brief statement of what has been done in the sea coast fisheries of the country, and now let us consider for a moment the results of inland fry planting. It seems scarcely necessary in a body of this kind

that I should call attention to the numerous and almost innumerable inland streams of the New England, middle and northern and northwestern states which have been restored from a decimated to excellently stocked streams. But let us go a step further. There never was a fairer field for the demonstration of success in fry planting than has been afforded in my own state of Michigan. Prior to 1841 the lower peninsula of Michigan was practicably a zoological desert as far as the brook trout was concerned. Fry planting has been going on under the efforts of the Michigan fish commission for the last eighteen years, but it cannot be said to have been adequately done in point of numbers until the years following 1880; yet for ten or twelve years fine trout fishing has been had in more than half of the counties of that peninsula, and with the advent of this spring the number of streams opened to public fishing has been largely increased, until it may now be said that brook trout can be had for the taking in fully two-thirds of the counties. This is in some measure true of the state of Wisconsin.

The Saranac lakes in New York furnish another evidence of the success of fry planting of whitefish under somewhat adverse circumstances, the lake in which they were introduced being filled with their natural enemies, and yet from a small plant made in this lake about the year 1885 we learn that adult fish have been taken.

All fishculturists who attempt to keep up their stock of parent fish by raising a certain quantity of fry each year are familiar with the great mortality occurring at the period when the young fish has finally absorbed his food sac, and is ready to take the natural food provided by nature. At this time when he "rises" in search of this natural food if he does not find it he is compelled to take the artificial food prepared for him, and the difficulty of adapting his stomach to this food results in a loss which varies somewhat from fifty to seventy-five per cent. If the young trout at this period of his existence were allowed to forage for his natural food this mortality would be greatly reduced. There are streams that are well known in Michigan which have had plants of fry not to exceed five hundred in number which within three years from the time of stocking have shown up well, and today without further stocking afford good sport to the angler.

Within the current month there appeared in the Detroit daily paper an interview with a prominent fishculturist who took occasion to say: "I believe, and against great opposition have always maintained, that 100,000 yearlings planted were more likely to live and thrive than 5,000,000 fry." Making due allowance for the enthusiasm of the interviewed party and for the natural predisposition of man to defend his pet theories, let us see where these figures would leave us.

We will start with 5,000,000 fry planted, and we will say that twenty-five per cent perished the first year, ten per cent the second year, and five per cent the third year. At the end of the second year after deducting the twenty-five per cent for loss, and estimating the number thus left to be composed of one-third females, which would cast on an average 250 eggs apiece, there would be added to the stock 281,250,000. Estimating that there will be a loss of seventy-five per cent of this number we have left 70,312,500. At the end of the third year we would have 1,068,750 spawning females casting on on an average 450 eggs each, amounting to 480,937,500. Deducting from this amount seventy-five per cent for loss, and we have left 120,234,375. These added to the original plant, after having

deducted therefrom for loss on the original plant twenty-five, ten and five per cent for the three years, and we have left as the result of a 5,000,000 plant 193,753,125.

Now let us take 100,000 yearling trout: At the end of the first year after planting we deduct ten per cent for the mortality in the adult fish which leaves us 90,000. Of this number one-third being females, we would have 30,000 spawning fish which would cast on an average of 250 eggs apiece. This would give us 7,500,000 and deducting 75 per cent for mortality we have left 1,875,000. At the end of the second year after planting after having deducted five per cent. loss for adult fish, 85,500. One-third of these being spawners, will cast 450 eggs, each amounting to 12,825,000. Deduct from this amount seventy-five per cent for mortality and we have left 3,206,250. At the end of the third year after having deducted five per cent for loss we have left 81,225 fish. One-third of this number being females will cast on an average 900 eggs to each fish amounting to 24,367,500. From this amount deduct seventy-five per cent for loss, leaving 6,091,875.

At the end of the third year we must also take into consideration the fry hatched from the fish hatched at the end of the first year which will have arrived at their first spawning age. This number will amount to 1,875,000. From this amount deduct twenty-five per cent for mortality and we have 1,406,250. One-third of these being females leaves 468,750 spawners which will cast 250 eggs apiece amounting to 117,187,500. Deducting from this quantity a loss of seventy-five per cent, and we have left 29,296,875. The above amounts added together make the total result of the planting of 100,000 yearling trout at the end of a three-year period amount to 40,551,225 as against 193,753,125 as the result of the fry planting of 5,000,000.

Considering the results, therefore, of fry planting, from which practically all the results we have are due, we must assume that it has been eminently successful, and when we consider the cheapness with which this work is done it would seem that the ample success of fry planting is simply incontestable.

FISH PLANTS, 1891-1892.

Whitefish plants, 1891, from Detroit house.

Name of waters.	Where planted.	Date.	Number.
Lake Michigan	Manistee	Mar. 30	4,000,000
Lake Michigan	South Haven	April 1	4,000,000
Lake St. Clair	Grosse Pointe	" 1	4,000,000
Lake Michigan	Ludington	" 2	4,000,000
Lake Michigan	Muskegon	" 3	4,000,000
Lake Michigan	St. Joseph	" 4	4,000,000
Lake Michigan	Frankfort	" 6	4,000,000
Lake Michigan	Pentwater	" 6	4,000,000
Saginaw Bay	Bay City	" 8	5,000,000
Lake Michigan	Grand Haven	" 9	3,000,000
Lake Michigan	Whitehall	" 9	3,000,000
Lake Michigan	Grand Haven	" 10	4,000,000
Lake Michigan	St. Joseph	" 11	3,000,000
Lake Michigan	Muskegon	" 13	3,000,000
Lake Huron	Sand Beach	" 13	4,000,000
Big Traverse bay	Traverse City	" 14	5,000,000
Lake Michigan	Ludington	" 15	4,000,000
Lake Michigan	South Haven	" 17	4,000,000
Lake Michigan	Manistee	" 18	3,000,000
Straits of Mackinac	Cheboygan	" 19	4,000,000
Straits of Mackinac	Mackinaw	" 21	5,000,000
Wild Fowl bay	Bay Port	" 21	5,000,000
Little Traverse bay	Petoskey	" 23	5,000,000
Straits of Mackinac	Mackinaw	" 23	5,000,000
Lake Huron	Sand Beach	" 27	5,000,000
Detroit river	Detroit	" 30	2,000,000
Total			104,000,000

Whitefish plants, 1892, from Detroit house.

Name of waters.	Where planted.	Date.	Number.
Detroit river	Belle Isle	Mar. 19	1,000,000
Lake Erie	Monroe	" 25	2,000,000
Lake Michigan	South Haven	" 30	2,500,000
Lake Michigan	Manistee	April 1	2,500,000
Lake St. Clair	Grosse Pointe	" 3	3,000,000
Detroit river	Grassy Island	" 4	2,000,000
Lake Michigan	Ludington	" 4	1,500,000
Detroit river	Belle Isle	" 5	3,000,000
Lake Michigan	Frankfort	" 5	3,000,000
Lake Michigan	Cheboygan	" 7	3,000,000
Lake Michigan	Grand Haven	" 8	3,000,000
Lake Michigan	Muskegon	" 8	3,000,000
Lake Huron	Sand Beach	" 13	3,000,000
Saginaw bay	Bay City	" 13	3,000,000
Lake Michigan	Pentwater	" 11	3,000,000

Whitefish plants, 1892, from Detroit house—CONTINUED.

Name of waters.	Where planted.	Date.	Number.
Straits of Mackinac	Mackinaw	April 14	3,000,000
Lake Michigan	Frankfort	" 14	3,000,000
Lake St. Clair	Grosse Pointe	" 16	4,000,000
Saginaw bay	Wild Fowl Bay	" 18	3,000,000
Lake St. Clair	Grosse Pointe	" 18	4,000,000
Torch lake	Elk Rapids	" 18	3,000,000
Straits of Mackinac	Mackinaw	" 19	3,000,000
Lake Erie	Newport	" 23	1,000,000
Lake Huron	Sand Beach	" 11	3,000,000
Total			65,500,000

Whitefish plants, 1892, from Sault Ste. Marie station.

Name of waters.	Where planted.	Date.	Number.
Lake Superior	Marquette	April 26	1,500,000
Lake Michigan	Manistique	May 12	2,000,000
Lake Superior	Marquette	" 16	1,500,000
Whitefish bay	Taquamenon	" 8	3,500,000
Sault Ste. Marie river	Sault Ste. Marie	" 16	1,224,000
Total			9,724,000

Brook trout plants, 1891.

County and name of waters.	Town.	Name of depositor.	Date.	Number.
Alcona:				
West branches of Pine river	Killmaster	H. M. Loud & Sons	May 26	12,000
Blockhouse creek	Potts	J. W. Morin	" 26	6,000
Mill creek	Harrisville	D. McGregor	" 26	25,000
Sucker creek	"	"	" 26	
West Branch creek	"	"	" 26	
Wolf creek	Mitchell	Lawrence R. Dorr	" 26	15,000
Silver creek	"	" "	" 26	
McGenn creek	"	" "	" 26	
Jim's creek	Haynes	Addison Silverthorn	" 26	6,000
North and south branches of Black river	Alcona	J. L. Sanborn	" 26	12,000
Allegan:				
North branch of Rabbit river	Wayland	Elias Sias	Feb. 19	9,000
Button's brook	Hopkins	Charles W. Button	" 19	3,000
Brows creek	Otsego	Ed. J. Anderson	" 19	9,000
Duncan creek	"	" "	" 19	
Yurrick's creek	"	J. N. Perkins	" 19	9,000
Watson creek	Watson	" "	" 19	
Munn's creek	Otsego	Conrad Brothers	April 10	9,000
Uhlem creek		" "	" 10	
Clifford creek	Otsego and Trowbridge	" "	" 10	
Day creek	Martin	J. D. Kelley	" 10	15,000
Billingham creek	"	" "	" 10	
Alpena:				
King creek	Wilson	Henry Bolton	Mar. 26	25,000
Bean creek	Ossineke	" "	" 26	
Norwegian creek	Alpena	Chris. O. Hammer	" 26	6,000
Smith creek	Green	D. D. Hanover	" 26	6,000
Spring lake and creek	Alpena	Jas. R. Conway	" 26	15,000

Brook trout plants, 1891—CONTINUED.

County and name of waters.	Town.	Depositor.	Date.	Number.
Antrim:				
Orr creek	Banks	C. S. Campbell	Mar. 16	12,000
Cedar river	Kearney and Mancelona	Oscar W. Kibby	" 16	15,000
Intermediate river	Kearney and Forest Home	" "	" 16	
Shanty creek	Chester	O. W. Holly	" 16	
Saloon creek	"	" "	" 16	12,000
Holly brook	"	" "	" 16	
Jordan river	Chestonia	Mich. Fish Com.	" 30	10,000
Arenac:				
Deep river	Deep River	A. C. Maxwell	" 26	15,000
Wells Creek	Moffat	Rich. Ronnallie	" 26	6,000
Baraga:				
Silver river	L'Anse	Wm. L. Mason	May 6	15,000
Falls river	"	" "	" 6	
Slate river	Avon	Chas. M. Turner	" 6	15,000
Barry:				
Yankee Springs creek	Yankee Springs	A. C. Hunt	Mar. 2	6,000
Glass creek	" "	J. W. Rogers	" 2	9,000
Coldwater creek	Woodland and Carlton	Oliver J. Wait	" 2	6,000
Spring brook	Irving	John C. Baker	" 18	6,000
Walker creek	Thornapple	John McQueen	" 18	6,000
White creek	"	" "	" 18	
Berrien:				
Mud run	Three Oaks	C. D. Brownell	Feb. 19	18,000
Spring creek	" "	" "	" 19	
Mill creek	Watervliet and Bainbridge	A. N. Woodruff	" 19	15,000
Edmons creek	Benton & B'nbridge	L. T. Burridge	Mar. 18	
Chadwick creek	" "	" "	" 18	
Eastman creek	" "	" "	" 18	
Blue creek	" "	" "	" 18	15,000
Sand creek	" "	" "	" 18	
Pipestone creek	" "	" "	" 18	
Brunson's creek	" "	" "	" 18	
Dages creek	Buchanan	Levi Redden	" 18	9,000
Valentine creek	Galien	L. Jeffries	Feb. 19	6,000
Peterbaugh creek	Berrien	Walter Kepphart	" 19	
Hickory creek	"	" "	" 19	12,000
Townsend creek	"	" "	" 19	
Galien river and branches	Three Oaks	Francis V. Martin	Mar. 18	6,000
Silver Semetra creek	Niles	G. W. Dougan	" 18	3,000
Calhoun:				
South branch of Mt. Jack creek	Newton & Leroy	C. B. Lowell	Feb. 23	6,000
Miseroll's creek	Burlington	L. L. Marsh	" 23	6,000
Foster Spring brook	Leroy	A. R. Thompson	" 23	
Brook creek	"	" "	" 23	9,000
Branch of Pine creek	"	" "	" 23	
Woodruff creek	Athens	Geo. W. Ferris	" 23	6,000
Ferris creek	"	" "	" 23	
Martin creek	Battle Creek	N. A. Osgood	Mar. 2	
Simons creek	Bedford	" "	" 2	
Quaker creek	Maple Grove	" "	" 2	
Foster creek	Newton	" "	" 2	18,000
Kelsey creek	Leroy	" "	" 2	
Crystal creek	Leroy & B'ttle Creek	" "	" 2	
Spring brook	" "	" "	" 2	
Wabacon creek	Bedford	C. R. Harris	" 2	
Gulfstream creek	Emmet	" "	" 2	
Seven mile creek	Bedford	" "	" 2	
Dixon brook	Marshall	" "	" 2	18,000
Neuman brook	Emmet & Bedford	" "	" 2	
Helmer creek	" "	" "	" 2	
Rice creek	Marshall & Marengo	Thos. L. Cronin	" 2	6,000
Gillet's creek	Clarence	F. C. Courter	" 2	2,000
Cass:				
Tryon brook	Wayne	E. Barton Jewell	" 18	6,000
Kensey's creek	Howard & Jefferson	B. D. Shaw	Feb. 19	9,000
Charlevoix:				
Hoffman's or Branch lake	Hudson	Timothy Carter	Apr. 17	15,000

Brook trout plants, 1891—CONTINUED.

County and name of waters.	Town.	Depositor.	Date.	Number.
Cheboygan:				
Cedar creek	Tuscarora	Henry J. Graves	Apr. 8	10,000
East branch of Sturgeon river	Burt and Ellis	" "	8	
Clark creek	Ellis	W. H. Merritt	" 8	6,000
Lillian creek	Mentor	" "	" 8	
Chippewa:				
Little and Big Rapids	Sault Ste. Marie	C. Robotham	" 2	30,000
Clare:				
Dock and Tom creek	Surrey	E. J. Roys	Mar. 30	8,000
Mill creek	Winterfield	Cairns E. Smith	" 30	6,000
Littlefield creek	Surrey	F. E. Presley	" 30	9,000
Clinton:				
Moon creek	Ovid and Duplain	A. M. Birmingham	Feb. 26	12,000
Bruice creek	Duplain	" "	" 26	
School Section creek	Essex	George Randolph	" 26	9,000
Spring brook	Eagle	Cassius Alexander	Mar. 5	6,000
Tubulan's creek	Lebanon	John Betts	" 23	3,000
Crawford:				
East branch of Au Sable river	Frederic	Elijah Flagg	Apr. 8	15,000
Au Sable river	"	" "	" 8	
Au Sable river	Grayling	D. H. Fitzhugh	" 17	25,000
Eaton:				
Spring brook	Eaton	G. W. Sherwood	Mar. 2	9,000
Stone Coal creek	Oneida	J. C. Holmes	" 5	6,000
Sand Stone creek	"	Richard Lawson	" 5	9,000
Newkirk brook	"	E. A. Marvin	" 23	9,000
Bull's run	Delta	S. J. Miller	" 23	6,000
Emmet:				
Big creek	Carp Lake	J. C. Schmalzreid	" 16	9,000
Spring creek	Maple River	E. S. Lyon	" 16	9,000
Willow brook	Maple Rv. & Carp L.	M. F. Quaintance	" 30	
Fountain spring brook	" "	" "	" 30	
Conway spring brook	" "	" "	" 30	
Wequetonsing brook	" "	" "	" 30	
Kegomis creek	" "	" "	" 30	27,000
Page creek	" "	" "	" 30	
Harding creek	" "	" "	" 30	
Nadolskis creek	" "	" "	" 30	
Minnehaha creek	" "	" "	" 30	
Maple river	Maple River	B. Hawkins	" 30	9,000
Genesee:				
Thread creek	Grand Blanc	Eli J. Jennings	" 11	9,000
Kersley creek	Atlas	" "	" 11	
Nickerson creek	Mayfield	C. E. Brewster	" 16	9,000
Grand Traverse:				
Mayfield creek	Paradise	C. E. Brewster	" 16	9,000
Payne creek	Paradise and Fife L.	T. M. Wilson	" 16	12,000
Knight creek	" "	" "	" 16	
Elk lake and three tributaries	Whitewater	H. H. Noble	" 16	24,000
Whitewater brook	"	Frank H. Vinton	" 16	12,000
Baker creek	"	" "	" 16	
Gratiot:				
Pine creek	Sumner and Crystal	J. B. Tucker	" 5	9,000
Ferris creek	Ferris	" "	" 5	
Hillsdale:				
Skinner's creek	Hanover	G. T. Greenshaw	Feb. 23	
Greenshaw brook	"	" "	" 23	9,000
Ramsdell brook	"	" "	" 23	
Headwaters of the Kalamazoo and Grand rivers	Moscow & Somerset	Chas. W. Harris	" 23	12,000
Spring brook	Hillsdale	Charles Morgan	Mar. 18	6,000
No name	"	J. Sampson	" 18	6,000
Willow creek	"	Hod. Gale	" 18	6,000
Spring brook	"	" "	" 18	
Iosco:				
Vaughn's creek	Plainfield	Warren S. Hodges	" 26	9,000
Ionia:				
Bellamy creek	Easton	H. L. Bailey	Feb. 3	
Session creek	Berlin	" "	" 3	20,000
Tibbitts creek	"	" "	" 3	
Prairie creek	Ronald	" "	" 3	

Brook trout plants, 1891—CONTINUED.

County and name of waters.	Town.	Depositor.	Date.	Number.
Ionia county—cont'd:				
Alden creek	North Boston	Chas. D. Pease	Feb. 26	2,000
Church creek	Boston	A. W. Huntley	" 26	12,000
Hawn creek	"	" "	" 26	
Tubulans creek	Lyons	John Betts	" 26	9,000
Struble creek	"	H. Hitchcock	Mar. 5	
East Libhant brook	"	"	" 5	
Lake brook	"	"	" 5	
Murphy's brook	"	"	" 5	12,000
Spring brook	"	"	" 5	
Spires brook	"	"	" 5	
Searney's brook	"	"	" 5	
Randall creek	Boston	James W. Toles	" 23	3,000
Monks creek	"	" "	" 23	
Deer-lick brook	North Plains	George A. Chatterton	" 23	
Popple creek	Randall	" "	" 23	
Dugway creek	Lebanon and North Plains	" "	" 23	15,000
Carpenter's creek	Crystal and Ferris	" "	" 23	
Spring creek	North Plains	" "	" 23	
No name	Portland	U. J. Maynard	" 23	6,000
Derby's creek	Derby and Sebena	H. L. Benschoter	" 23	6,000
Steel creek	Ionia	H. L. Bailey	Apr. 7	
East creek	"	" "	" 7	12,000
Crystal creek	"	" "	" 7	
Outlet of Cryderman lake	Danby	Geo. D. Allen	" 7	12,000
Isabella:				
McDonald creek	Vernon	Allen McDonald	Mar. 11	6,000
Baker creek	"	J. H. Seeley	" 11	6,000
Big Cedar creek	Fremont	Geo. L. Granger	" 11	6,000
Johnson creek	Union	" "	" 11	
Jackson:				
Farmers' creek	Pulaski	L. N. Keeler	Feb. 23	6,000
Mill creek	Summit	C. B. Bush	" 23	6,000
Outlet of Gillets lake	Leoni	Geo. E. Beebe	" 23	6,000
Willow brook	Grass Lake	Samuel Campbell	" 23	6,000
Spring brook	Concord	F. C. Courter	Mar. 2	4,000
Rice brook	"	" "	" 2	
Kalamazoo:				
Davis creek	Cooper	Ed. J. Anderson	Feb. 19	9,000
Travis creek	"	" "	" 19	
Coldstream brook	Alamo	E. C. Adams	" 19	6,000
Shaffers brook	Kalamazoo & Cooper	Wm. A. Glover	" 19	
Parker brook	" "	" "	" 19	9,000
Leeper brook	" "	" "	" 19	
Spring brook	" "	" "	" 19	
Collier brook	Kalamazoo	J. Frank Cargill	" 19	
North Stacy brook	Richland	" "	" 19	6,000
South Stacy brook	"	" "	" 19	
Harrison's creek	Prairie Ronde	Thomas Hewitt	" 23	3,000
Whitford creek	Charleston	H. Dale Adams	" 23	6,000
Sumner creek	Comstock	" "	" 23	
Boles or Stanley creek	Portage	Thomas Hewitt	" 18	12,000
Augusta creek	Ross	Chas Polley	" 18	15,000
Kent:				
Davis creek	Algoma & Plainfield	Neal McMillan	Feb. 19	
Rum creek	" "	" "	" 19	12,000
Whitney creek	" "	" "	" 19	
Allen creek	Algoma	J. Coon	" 19	
Austin creek	Algoma and Courtland	"	" 19	
Clear creek	Cannon	"	" 19	12,000
Hutchings creek	Algoma	"	" 19	
Bowne creek	Bowne	Lewis Kelley	" 19	6,000
Braisted creek	Lowell	Frank Braisted	" 19	6,000
Hendricks creek	Gaines	A. W. Blain	Mar. 2	3,000
Cooley's creek	Caledonia	Henry N. Cooley	" 2	3,000
Stow creek	"	D. P. Hale	" 2	3,000
County Line creek	Solon	J. V. Crandall	Feb. 26	3,000
Muro's creek	Algoma	Homer B. Stevens	" 26	
Neenan's pond	"	" " "	" 26	9,000
Anderson's pond	Courtland	" " "	" 26	
Clear creek	Spencer	T. I. Phelps	Mar. 5	15,000
Wabsis creek and lake	Oakfield	" "	" 5	
Sparta creek	Sparta, Solon & Algoma	Arthur A. Place	" 9	15,000
Silver creek	" " "	" " "	" 9	
Crinion creek	Courtland, Oakfield and Spencer	Freeman Addis	" 18	9,000
Silver creek	Wyoming	H. W. Davis	" 18	6,000

Brook trout plants, 1891—CONTINUED.

County and name of waters.	Town.	Depositor.	Date.	Number.
Kent county—cont'd:				
Clear creek	Sparta	C. C. Darling	Apr. 10	12,000
Mink creek	Alpine and Sparta	Frank Baird	" 10	12,000
Buck creek	Wyoming	A. A. Crippen	" 10	15,000
Cedar creek	Algoma	W. R. Holden	May 12	8,000
Cedar creek	Solon	" "	" 12	
Seeley creek	Grattan	C. M. Slayton	Mar. 5	9,000
Snow creek	Lowell	C. D. Pease	Feb. 26	
Cherry creek	Vergennes & Lowell	" "	" 26	10,000
Kopf creek	Lowell	" "	" 26	
Church creek	Cascade	" "	" 26	
Tributary to Buck creek	Paris	N. Bourna	Mar. 18	9,000
Lake:				
Silver creek	Cherry Valley	Jay Sprague	" 9	3,000
Lapeer:				
Gutches creek	Almont	F. P. Andrus	Feb. 26	5,000
South branch of Mill creek	Attica	Peter Holmes	Mar. 2	12,000
Hemmingway and Elk creeks	Marathon	John D. Brown	" 2	9,000
Townsend creek	Metamora	Ira Reed	" 23	6,000
North branch of Clinton river	Almont	M. E. Martin	" 26	6,000
Lenawee:				
Bear creek	Hudson	James B. Thorn	" 18	
Tiffin river	"	" " "	" 18	12,000
Hillsdale creek	"	" " "	" 18	
Gleason brook	Madison, Palmyra and Ogden	Myron D. Pierce	" 18	6,000
Gragg creek	Clinton	C. D. Keyes	" 18	9,000
Smalley creek	Clinton & Franklin	" "	" 18	
Smalley creek	" "	H. H. Halladay	" 18	3,000
Little Raisin river	Ridgeway	T. H. Temple	Feb. 23	6,000
Private pond	Rollin	H. Smith	Mar. 18	6,000
Livingston:				
Appleton creek	Genoa & Hamburg	C. E. Cushing	Mar. 5	
Walker creek	" "	" "	" 5	
West Woodruff creek	Brighton	" "	" 5	20,000
East Woodruff creek	"	" "	" 5	
School creek	Hamburg	Will Cady	Apr. 4	9,000
Leelenaw:				
Branch of Cedar run	Solon	James G. Johnson	Mar. 16	15,000
Macomb:				
North branch of Clinton river	Bruce	R. B. Owen	Feb. 26	6,000
East branch of Stony creek	"	" "	" 26	6,000
Smith's creek	"	F. P. Andrus	" 26	4,000
Wilson's creek	Washington	Andrews and Stewart	Mar. 23	9,000
No name	Harrison	J. S. Farrar	May 8	10,000
Mackinac:				
Hurlburt lake	St. Ignace	F. R. Hurlburt	Apr. 2	9,000
Tributary to Brevoort lake	Hendricks	M. Mulcrome	" 2	10,000
McGraw's creek	Holmes	W. L. Benham	May 6	
Lundlum creek	"	" "	" 6	20,000
Sandigo creek	"	" "	" 6	
Manistee:				
Fowler's creek	Manistee	G. R. Fowler	Mar. 9	6,000
Beaver creek	Maple Grove	F. A. Mitchell	" 9	9,000
Spring creek	" "	" "	" 9	
Gable creek	Cleon	Wm. R. Smith	" 30	12,000
East branch of Bear creek	"	" "	" 30	
Sickels creek	Brownstown	H. A. Bahr	" 9	3,000
Boyd's creek	Marilla	James H. Winters	" 9	
Pepples creek	"	" " "	" 9	9,000
Huddleston creek	"	" " "	" 9	
Sickels creek	Brown	John Sickels	" 9	6,000
Marquette:				
Silver creek	Ishpeming	Geo. A. Newett	May 6	
Lake Sally	Tilden	" "	" 6	
North lake	Ely	" "	" 6	30,000
Green creek	Town 47	" "	" 6	
Pijiki river	Michigamme	John C. Fowle	" 6	15,000
Laughing Fish creek	Onoto	Horatio Seymour	" 6	
Dead river	Marquette	" "	" 6	20,000
Chocolay river	Chocolay	" "	" 6	

Brook trout plants, 1891—CONTINUED.

County and name of waters.	Town.	Depositor.	Date.	Number.
Mason:				
Carr Settlement creek	Branch	B. F. Barnett	Mar. 9	9,000
Genson creek	Sherman	James R. Barnes	" 9	6,000
Erne stream	Riverton	Erne & Rumberger	" 9	9,000
Cook creek	"	" "	" 9	
N. branch of Little Sable river	Victory	Jasper N. Clark	" 9	9,000
New creek	Amber	George Sindear	" 9	6,000
Spring creek	"	V. R. Penney	" 9	6,000
Quinn creek	Riverton	D. C. Wickham	" 13	9,000
Nickerson creek	"	" "	" 13	
Mecosta:				
Handy creek	Deerfield	J. C. Boyd	Feb. 19	
Sand brook	"	" "	" 19	
Quigle creek	"	" "	" 19	15,000
Stevens stream	Winfield	" "	" 19	
Hinton creek	Hinton and Morton	C. M. Helms	" 19	
Simmons creek	" " "	" "	" 19	
Tellerhoff creek	Hinton	" "	" 19	21,000
Hiberger creek	Deerfield & Austin	" "	" 19	
Mills creek	Deerfield	" "	" 19	
Headwaters N. Br. of Pine river	Millbrook	H. P. Blanchard	Mar. 5	12,000
Mack creek	Mecosta	George Reed	Apr. 6	9,000
Parish creek	Green	James Parkhill	" 8	12,000
Montcalm:				
Two small streams, no name	Montcalm	H. L. Bailey	" 7	6,000
Rice creek	Pierson & Reynolds	S. V. Bullock	Feb. 26	6,000
Spring brook	Day	S. Frost	Mar. 5	6,000
Little Pine creek	Ferris and Crystal	J. E. Youndan	" 5	12,000
Town Line creek	Winfield and Maple Valley	J. A. Barry	" 5	6,000
Jones creek	Homer	Wm. R. Jones	" 5	9,000
Brandy creek	Winfield	M. W. Kelsey	" 5	9,000
Dickson creek	Douglass, Sidney and Fairplain	T. I. Phelps	" 5	9,000
Wabasis creek	Eureka	W. R. Holden	May 12	5,000
Indian creek	Reynolds	R. O. Donald	Apr. 29	15,000
Muskegon:				
Musquito creek	Eggleston	C. L. Gunn	Mar. 13	6,000
Boyne creek or Spring brook	Norton	O. P. Barcus	" 13	6,000
Dalton creek	Montague	George Klett	" 13	3,000
Mack creek	Edgerton	W. R. Holden	May 12	4,000
Big Crockery creek	Moorland	" "	" 12	4,000
Duck creek	Muskegon	E. D. Magoon	Apr. 20	15,000
Montmorency:				
Cold creek	Rush	E. H. Gillman	Mar. 26	
Weber creek	"	" "	" 26	
Bolton creek	"	" "	" 26	
Avery creek	"	" "	" 26	40,000
Outlet to Turtle lake	"	" "	" 26	
Dollar pond	"	" "	" 26	
Hay Meadow creek	Briley	W. L. Leach	" 26	
Stanager creek	Albert	" "	" 26	18,000
Bargehr creek	Briley	" "	" 26	
Newaygo:				
Freeman creek	Troy	Albertus Andres	Mar. 9	
Upper Pere Marquette river	Beaver	" "	" 9	18,000
Pickerel creek	Troy	" "	" 9	
Brooks creek	Brooks & Garfield	Chas. Kritzer	" 9	6,000
Chidester creek	Bridgeton	W. S. Barton	" 9	9,000
Williams creek	Sheridan, Sherman and Brooks	Andrew Gerber	" 13	
Helster creek	Dayton	" "	" 13	18,000
Black creek	Dayton & Denver	" "	" 13	
Kemp or Big Gully creek	Sheridan	" "	" 13	
Loutier creek	Dayton	Frank Cole	" 13	
Odell creek	"	" "	" 13	18,000
Cole creek	"	" "	" 13	
Hatches creek	Barton	Albert T. Wightman	Apr. 4	6,000

Brook trout plants, 1891—CONTINUED.

County and name of waters.	Town.	Depositor.	Date.	Number.
Oakland:				
Outlet to Walnut lake	West Bloomfield	Frank Park	Feb. 26	6,000
Buckhorn creek	Rose	E. A. Botsford	Mar. 11	6,000
Outlet to Long and Gilbert lakes	Bloomfield	S. Alexander	" 23	6,000
Farmington brook	Farmington and Livonia	Lewis Walker	" 23	12,000
Moyers spring and tributaries	Oxford	O. E. Bell	" 23	9,000
Indian Garden lake and brook	Milford	E. J. Bissell	" 23	6,000
Oceana:				
Sand creek	Otto	C. E. Covell	" 13	6,000
Cob-moo-sa creek	Terry & Elbridge	Jesse Walker	" 13	9,000
Cunningham creek	Newfield	Horace Lattin	" 13	9,000
Ogemaw:				
Hubbard creek	West Branch	S. V. Thomas	" 26	15,000
South branch of Klacking creek	Klacking	Harvey C. Leonard	" 26	9,000
Headwaters of Au Sable river	Goodar	John O'Connor	" 26	9,000
E. br. of Tittabawassee river	Horton	C. N. Ashford	" 26	18,000
Ammond creek	Cummings & Kl'k'g	Jerry Ammond	" 26	6,000
Cold creek	Goodar	Charles Taylor	" 26	6,000
South branch of Au Sable river	"	Albert H. Carter	" 26	6,000
Mackies creek	West Branch	James Mackie	" 26	6,000
Osceola:				
Big Stone creek, two branches	Evart and Hersey	J. W. Brigham	" 11	15,000
Chippewa creek	Osceola	F. S. Severen, M. D.	" 11	6,000
Beaver creek	Le Roy	Dell Roberts	" 16	9,000
Deacy's creek	Evart	James Deacy	" 11	6,000
West branch of Clam river	Park Lake	M. L. Rice	" 30	9,000
Middle Br. of Muskegon river	Marion	J. Desbrow	" 30	8,000
Brooks creek and tributaries	Sylvan	Jacob J. Reick	" 30	12,000
Sylvan creek and tributaries	"	" "	" 30	
Finney creek and tributaries	"	" "	" 30	
Comstock creek	Evart and Osceola	Peter Comstalk	" 30	6,000
Brooks creek and tributaries	Sylvan	Jacob J. Reick	" 11	18,000
Sylvan creek and tributaries	"	" "	" 11	
Finney creek	"	" "	" 11	
Oscoda:				
Big creek	Luzerne	Stewart Gorton	" 26	18,000
Silver creek	Comins	C. M. Comins	" 26	12,000
Otsego:				
Stacey creek	Corwith	D. H. Fitzhugh	Apr. 8	15,000
East branch of Sturgeon creek	"	" "	" 8	
West branch of Sturgeon creek	" & Otsego	J. A. Waggoner	" 8	15,000
Outlet of Bradford lake	Otsego Lake	H. Stephens	" 17	15,000
Branch of Au Sable river	Town 27 N. R 4 W.	"	" 17	15,000
East Branch of Sturgeon river	Otsego	D. H. Fitzhugh	" 8	10,000
Ottawa:				
Branch of Rush creek	Georgetown	B. E. Green	Feb. 19	9,000
Milk creek	Jamestown	Francis J. Buege	" 23	9,000
Black creek	"	" "	" 23	
Branch of Rush creek	Georgetown	Hiram Haight	Mar. 18	6,000
Branch of Big Crockery	Chester	W. R. Holden	" 12	4,000
Presque Isle:				
Lake Esau	Presque Isle	Wm. A. French	" 26	15,000
Roscommon:				
Robinson creek	Higgins	H. H. Woodruff	" 26	12,000
St. Clair:				
Silver creek	Grant	Hugh Stevenson	Feb. 26	12,000
St. Joseph:				
Mill creek	Mottville	Charles Rice	" 23	12,000
Spring run	Flowerfield	"	" 23	
Tuscola:				
Sucker creek	Ellington	F. S. Wheat	Mar. 2	9,000
White creek	Indian Fields and Wells	"	" 2	
Butternut creek	Indian Fields	J. H. Howell	" 23	6,000

Brook trout plants, 1891—CONTINUED.

County and name of waters.	Town.	Depositor.	Date.	Number.
Van Buren:				
Hayden's creek	Almena	George Langdon	Feb. 19	6,000
Tributary to Paw Paw river	Antwerp	James W. Clark	" 19	6,000
Sink brook	Almena	T. A. Sprague	" 19	6,000
Barrett creek	Hamilton	Milton Barrett	" 19	6,000
Pine creek	Hartford & Keeler	A. H. Young	" 19	12,000
Butternut creek	Geneva	J. C. Merson	" 19	18,000
Cedar creek	" and Covert	"	" 19	
Spring brook	Antwerp	H. P. Waters	Apr. 10	12,000
Washtenaw:				
Honey creek	Ann Arbor	John F. Lawrence	Mar. 2	9,000
Private pond	Ypsilanti	John Gilbert	" 2	3,000
No name	Dexter	J. V. N. Gregor	" 18	6,000
Wexford:				
Fairchild's creek	Cherry Grove	D. F. Diggins	" 30	12,000
North branch of Pine river	" "	" "	" 30	
Slagal creek	Boon	B. Cooley	" 30	6,000
Harris lake and creek	Colfax	Hiram Harris	" 30	9,000
Downing creek	S. Br. & Henderson	Chittenden, Herrick & Co	" 16	12,000
Hoxey creek	" "	" "	" 16	
Total				2,500,000

Brook trout plants, 1892.

County and name of waters.	Town.	Depositor.	Date.	Number.
Alcona:				
Van Ettan creek	Mikado	Philip O. Partridge	Mar. 16	18,000
Indian creek	"	Ambrose Thompson	" 16	15,000
Spring creek	"	" "	" 16	
Jim's creek	Haynes	Addison Silverthorn	" 16	15,000
Sucker's creek	Alcona	D. McGregor	" 16	18,000
West branch	Haynes	" "	" 16	
Wolf creek	Mitchell	Lawrence R. Dorr	" 16	15,000
Silver creek	"	" "	" 16	
McGenn creek	"	" "	" 16	
South branch of Black river	Alcona	J. L. Sanborn	" 16	18,000
North branch of Black river	"	" "	" 16	
Allegan:				
Duncan creek	Gun Plains	Ed. J. Anderson	" 7	5,000
Scott creek	Lee and Casco	George Moore	" 7	15,000
Manlius creek	Manlius	Clinton B. Conger	" 7	18,000
North branch of Rabbit river	Wayland	Elias Sias	Feb. 29	9,000
Barn's brook	Trowbridge	C. Engle	" 29	3,000
Big creek	Martin	J. D. Kelley	" 29	6,000
Bellingham creek	"	" "	" 29	
Bagley pond tail race	Orangeville	" "	" 29	
Clifford creek	Trowbridge & Otsego	Conrad Brothers	" 29	6,000
Yarrick's creek	Otsego	John N. Perkins	" 29	6,000
Button's brook	Hopkins	Charles W. Button	" 29	3,000
Alpena:				
Norwegian creek	Alpena	Christ. O. Hammer	Mar. 16	15,000
Smith creek	Green	D. D. Hanover	" 16	15,000
Spring lake and creek	Alpena	James R. Conway	" 16	15,000
Antrim:				
Shanty creek	Custer	O. W. Holly	April 4	12,000
Saloon creek	"	" "	" 4	
Holly's brook	"	" "	" 4	
Orr creek	Banks	C. S. Campbell	" 4	15,000
N. and S. branches Jordan river	Alba	G. R. & I. R. R. agent	Mar. 28	25,000
Arenac:				
Branch of Au Gres river	Turner	J. A. Walker	" 16	18,000
Deep river	Deep river	A. C. Maxwell	" 16	10,000

Brook trout plants, 1892.—CONTINUED.

County and name of waters.	Town.	Depositor.	Date.	Number.
Barry:				
Yankee Springs creek	Yankee Springs	A. C. Hunt	Feb. 29	9,000
White creek	Thornapple creek	John McQueen	Mar. 10	10,000
Leonard creek	" "	" "	" 10	
Berrien:				
Farmer's brook	Pipestone	Charles K. Farmer	" 7	10,000
Pipestone creek	Sodus & Pipestone	L. T. Burridge	" 7	15,000
Bronson creek	" "	" "	" 7	
Edmond's creek	" "	" "	" 7	
Chadwick creek	" "	" "	" 7	
Penterbaugh creek	Berrien	Walter Kephart	" 7	15,000
Hickory creek	Oronoko and Lake	Levi Redden	" 7	10,000
Townsend creek	Berrien	" "	" 7	
Daye's brook	Buchanan	" "	" 7	
Estes brook	"	" "	" 7	
Mill creek and tributaries	Watervleit & Bainbridge	A. N. Woodruff	" 7	10,000
Cass:				
Kensey's creek	Howard & Jefferson	B. D. Shaw	" 7	10,000
Calhoun:				
Dixon creek	Marshall	C. R. Harris	" 7	25,000
Seven Mile creek	Bedford	" "	" 7	
Waboacon creek	"	" "	" 7	
Gulf stream	"	" "	" 7	
Cox brook	Emmet	" "	" 7	
Pratt brook	Bedford	" "	" 7	
Mineral Spring brook	Battle Creek	" "	" 7	
Austin brook	" "	" "	" 7	
Partridge Spring brook	Bedford	" "	" 7	
Helmer brook	Emmet	" "	" 7	
Newman's brook	Bedford	" "	" 7	
Mt Jack Spring brook	Newton and Leroy	C. B. Lowell	" 7	10,000
Hinkle's creek	Marshall	J. F. Garwood	" 7	10,000
Talmadge brook	"	" "	" 7	
Charlevoix:				
N. & S branches of Boyne river	Boyne Falls	G. R. & I. R. R. ag't.	" 28	30,000
Cheboygan:				
Black creek	Bentley	Everett J. Roos	" 22	10,000
Cedar creek	Tuscarora	Henry J. Graves	" 22	12,000
E. branch of Little Sturgeon	Burt and Ellis	" "	" 22	
Clark creek	Ellis	W. H. Merritt	" 22	10,000
Lillian creek	Mentor	" "	" 22	
Clare:				
Town Line creek	Frost	W. W. Green	" 14	25,000
Littlefield creek	Farwell	F. E. Presley	Feb. 26	9,000
Clinton:				
Spring brook	Eagle	Cassius Alexander	Mar. 2	10,000
High bank creek	Lebanon	John Betts	" 14	15,000
Hayworth creek	Essex	O. D. Casterline	" 14	12,000
School section creek	Maple Rapids	George Randolph	" 14	15,000
Moore's creek	Duplain	A. M. Birmingham	" 14	15,000
Bruice creek	"	" "	" 14	
West branch of Maple river	Ovid	" "	" 14	
Curtis creek	Duplain	A. E. Cobb	" 14	15,000
Crawford:				
Au Sable river	Grayling	D. H. Fitzhugh	" 26	10,000
Eaton:				
Bull's creek	Delta	S. J. Miller	" 2	10,000
Sandstone creek	Oneida	J. Carlisle Holmes	" 2	10,000
Stone coal creek	"	Richard Lawson	" 2	10,000
Newkirk creek	"	E. A. Marvin	" 2	10,000
Spring brook	Eaton	G. W. Sherwood	" 2	12,000
Butternut creek	"	" "	" 2	
Emmet:				
Spring creek	Maple river	E. L. Lyons	April 4	6,000
Big creek	Carp lake	J. C. Schmalzreid	" 4	6,000
Tributary to Maple river	Maple river	Wm. Fitzgerald	" 4	10,000
Maple river	Levering	G. R. & I. R. R. agt.	Mar. 28	15,000
Carp river	Carp lake	" " "	" 28	15,000

Brook trout plants, 1892.—CONTINUED.

County and name of waters.	Town.	Depositor.	Date.	Number.
Grand Traverse:				
Payne creek	Faradic & Fife Lake	T. M. Wilson	April 4	10,000
Knight creek	" " "	" "	" 4	
Tributary to Platt river	Long lake	J. M. Thomas	" 4	10,000
Gratiot:				
Pine creek	Sumner	J. B. Tucker	Mar. 2	18,000
Ferris creek	Ferris, Montcalm Co.	" "	" 2	
Pine river	Mecosta, Montcalm, Gratiot and Midland Cos.	" "	" 2	
Hillsdale:				
Greenshaw's spring	Hanover	G. T. Greenshaw	" 10	10,000
Ramsdell spring	"	" "	" 10	
Skinner's creek	"	" "	" 10	
Iosco:				
Vaugh creek	Plainfield	Warren S. Hodges	" 16	18,000
Isabella:				
McDonald creek	Vernon	Allen McDonald	" 16	15,000
Ionia:				
Steel creek	Ionia	H. L. Bailey	Mar. 2	3,000
East creek	"	" "	" 2	
Duck creek	Campbell	Samuel W. Burt	" 2	12,000
Clear creek	Portland	U. J. Maynard	" 7	10,000
Church creek	Boston	A. W. Huntley	" 14	15,000
Hawn creek	"	" "	" 14	
Jackson:				
Farmers' creek	Pulaski	L. N. Keeler	" 7	10,000
Mills creek	Summit	C. B. Bush	" 10	15,000
Kalkaska:				
South Br. of Boardman river	South Boardman	G. R. & I. R. R. agent	" 28	15,000
North Br. of Boardman river	Kalkaska	" " " "	" 28	15,000
Rapid river	Leelsville	" " " "	" 28	15,000
Kalamazoo:				
Davis creek	Cooper	Ed. J. Anderson	" 7	10,000
Travis creek	"	" "	" 7	
Lawler creek	Charleston	H. Dale Adams	" 7	10,000
Sumner creek	Comstock	" "	" 7	
Pursel creek	Prairie Ronde	Henry I. Allen	Feb. 29	6,000
Harrison creek	"	" "	" 29	
Mill creek	"	John E. Pabst	" 29	6,000
Shutes creek	"	" "	" 29	
Crooks creek	"	" "	" 29	
Lanes creek	Portage	Charles S. Bolles	" 29	6,000
Teakes creek	Schoolcraft	" "	" 29	
Black river	Prairie Ronde	Thomas Hewitt	" 29	6,000
Boles or Stanley creek	Portage	" "	" 29	
Collier creek	Cooper	J. Frank Cowgill	" 29	10,000
North Stacey creek	Richland	" "	" 29	
South Stacey creek	"	" "	" 29	
Pierson's creek	Alamo	Levi T. Fox	" 29	6,000
Kent:				
Hanley creek	Sparta	Arthur A. Place	" 29	12,000
English creek	"	" "	" 29	
Camp creek	"	" "	" 29	
Moffit creek	Caledonia	Hilbert Moffit	Mar. 10	6,000
Clear creek	Sparta	C. C. Darling	Feb. 29	3,000
Mink creek	Alpin and Sparta	Frank Baird	" 29	3,000
Buck creek	Wyoming	A. A. Crippen	" 29	3,000
Silver creek	"	H. W. Davis	" 29	3,000
Sugar Bush creek	Oakfield	A. W. Stevens	" 29	5,000
Muro's pond	Algoma	Homer B. Stevens	" 29	9,000
Newman's pond	"	" "	" 29	
Anderson's pond	Courtland	" "	" 29	
Allen creek	Algoma	J. Coon	" 29	12,000
Austin's brook	Algoma & Courtl'nd	"	" 29	
Clear creek	Cameron	"	" 29	
Hutching's creek	Algoma	"	" 29	
Crimion creek	Courtland, Oakfield and Spencer	Freeman Addis	" 8	10,000
Morris creek	Nelson	W. H. Wheeler	" 8	10,000
Spring creek	Solon	" "	" 8	
Sand creek	Grand Rapids	J. P. Wilson	" 8	5,000

Brook trout plants, 1892.—CONTINUED.

County and name of waters.	Town.	Depositor.	Date.	Number.
Lake:				
Danaher creek	17 N. 13 W.	J. B. Peter	Apr. 6	10,000
North Br. of Pere Marquette	Chase	W. F. Potter	" 6	20,000
Sanborn creek	Nirvana	" "	" 6	20,000
Baldwin creek	Baldwin	" "	" 6	10,000
Avery creek	"	" "	" 6	10,000
Kinney creek	"	" "	" 11	15,000
Lapeer:				
Gutches creek	Almont	F. P. Andrus	Mar. 2	7,500
Leelanaw:				
Branch of Cedar run	Solon	James G. Johnson	Apr. 4	12,000
Livingston:				
Beach creek	Hartland	H. S. Holdridge	Mar. 14	6,000
Appleton creek	Genoa	C. E. Cushing	" 2 }	12,000
Walker creek	Hamburg	" "	" 2 }	
Lenawee:				
Gragg creek	Clinton	C. D. Keyes	" 10	15,000
Smalley creek	Franklin & Clinton	H. H. Halladay	" 10	6,000
Gleason creek }	{ Madison, Palmyra	Myron J. Pierce	" 10 }	12,000
Big Meadow creek }	{ and Ogden	" "	" 10 }	
West branch of River Raisin	Rome	John H. Combs	" 10	10,000
Bean creek or Tiffin river	Hudson	James B. Thorn	" 10 }	15,000
Hillsdale creek	"	" "	" 10 }	
Macomb:				
Smith's creek	Bruce	F. P. Andrus	" 2	7,500
Manistee:				
Gable creek	Copemish	W. R. Smith	Feb. 25 }	15,000
East branch of Bear creek	"	" "	" 25 }	
Beaver creek	Maple Grove	J. A. Higgins	" 25	10,000
Fowler's creek	Manistee	G. R. Fowler	" 25	6,000
Clear brook	Brownstown	Loren Pearce	" 25	6,000
Mason:				
Carr Settlement creek	Lake and Branch	B. F. Barnet	" 25	10,000
Swan creek	Riverton and Eden	P. F. Harley	" 25	6,000
Butler creek	Riverton & Mason	Harmon & Remberger	" 25 }	12,000
Pardy creek	" "	" "	" 25 }	
Cedar creek	" "	" "	" 25 }	
Erne stream	Sherman	James R. Barnes	" 25 }	3,000
Cook creek	"	" "	" 25 }	
Ginson creek	"	" "	" 25 }	
Spring creek	Amber	V. R. Penney	" 25	3,000
Two inlets to Round lake	Sheridan	Chas. O. Holmes	" 25	3,000
Great Sable river	Bachellor	W. F. Potter	Apr. 6	15,000
Mecosta:				
Hinton creek	Hinton and Morton	C. M. Helmes	Feb. 8 }	25,000
Simmons creek	" "	"	" 8 }	
Mills creek	Deerfield	"	" 8 }	
Hiburger creek	Deerfield & Austin	"	" 8 }	
Fetterhoff	Hinton	"	" 8 }	
Sand brook	Deerfield	James C. Boyd	" 8 }	15,000
Quigle creek	"	"	" 8 }	
Handy creek	"	"	" 8 }	
Buckhorn creek	Green	Michigan Fish Com.	Apr. 12 }	20,000
Cheney creek	"	" " "	" 12 }	
Missaukee:				
Wallis creek	Lake	G. W. Crosby	Feb. 25	6,000
Headwaters of W. Br. of Muskegon river	"	James McGiness	" 25	16,000
Montmorency:				
Beaver creek	Rust	Philip Klein	Mar. 16	12,000
Hardwood creek	"	Silas S. Cohoon	" 16	12,000
Stony creek	"	Conrad Weingarth	" 16	12,000
Montcalm:				
Dickson creek	Douglass, Sidney and Fairplain	T. I. Phelps	" 2 }	15,000
Clear creek	Maple Valley	"	" 2 }	
Jones creek	Home	Wm. R. Jones	" 2	12,000
Black creek	Maple Valley	J. A. Dockery	" 7	10,000

Brook trout plants, 1892.—CONTINUED.

County and name of waters.	Town.	Depositor.	Date.	Number.
Muskegon:				
Crockery creek	Moorland & Casnovia	E. T. Slocum	Feb. 29	10,000
Little Cedar creek	Cedar Creek	John Dagen	Mar. 4	15,000
Cedar creek	Holton	Stephen S. Skeels	" 4	10,000
Skeels creek	"	" "	" 4	
Norris creek	Fruitport	C. C. Tuxbury	" 4	15,000
Duck creek	Fruitland	E. D. Magoon	" 4	15,000
Mosquito creek	Eggleston	C. L. Gunn	" 4	15,000
Belleview trent creek	Fruitland	W. C. Weige	" 4	6,000
Dalton creek	Montague	George Klett	" 4	6,000
Newaygo:				
Chidester creek	Bridgeton	W. S. Bartron	Feb. 29	10,000
Hatches creek	Barton	A. S. Wightman	Apr. 13	4,000
Williams creek	Sheridan, Sherman and Brooks	A. Gerber	Mar. 4	
Hester creek	Dayton	"	" 4	18,000
Black creek	"	"	" 4	
Loutier creek	"	Frank Cole	" 4	
Odell creek	"	" "	" 4	15,000
Cole creek	"	" "	" 4	
Oakland:				
Moyers spring and tributaries	Oxford	O. E. Bell	" 2	15,000
Outlet to Long and Gilbert lakes	Bloomfield	S. Alexander	" 2	15,000
Andrus creek	Highland	H. S. Holdridge	" 14	12,000
Pleasant Valley creek	Milford	" "	" 14	
Oceana:				
Cushm creek	Greenwood	Stephen S. Skeels	" 4	5,000
Cedar creek	Pentwater	D. C. Wickland	" 4	15,000
Annly creek	"	" "	" 4	
Cob-moo-sa creek	Ferry and Elbridge	Jesse Walker	" 4	10,000
Sand creek	Otto	C. E. Covell	" 4	10,000
Ogemaw:				
Headwaters of Klacking creek, south branch	Klacking	Harvey C. Leonard	" 22	16,000
Headwaters of S. branch of Au Sable river	Goodar	John O'Connor	" 22	10,000
Mackie's creek	West Branch	James Mackie	" 22	10,000
No name	T. 22 N., range 2 E.	S. V. Thomas	" 22	6,000
Cold creek	Goodar	Charles Toles	" 22	5,000
South branch of Sable river	"	Albert H. Carter	" 22	5,000
Oscoda:				
Glennie brook	Cummins	Joseph Sullivan	" 16	18,000
East branch of Big creek	Atherton	Stewart Gorton	" 26	
West branch of Big creek	Mount Pindus	" "	" 26	18,000
Big creek	" "	" "	" 26	
Osceola:				
West branch of Clam river	Park Lake	M. L. Rice	Feb. 25	10,000
Middle Br. of Muskegon river	Marion	G. Disborn	" 25	12,000
Chippewa creek and pond	Osceola	F. S. Sovereen, M. D.	Mar. 14	10,000
Deacey's pond and creek	Evart	James Deacey	" 14	16,000
Comstalk creek	Evart and Osceola	Peter Comstalk	" 14	16,000
Hofmeyers creek	Osceola and Sylvan	J. J. Reik	" 14	
Grindstone creek	Sylvan & Hartwick	"	" 14	
Thorn creek	Osceola and Evart	"	" 14	25,000
Sylvan creek	Sylvan	"	" 14	
Coles creek	Evart	"	" 14	
Le Roy creek	Le Roy	G. R. & I. R. R. agent	" 28	15,000
Ottawa:				
Milk creek	Jamestown	Francis J. Buege	Mar. 29	12,000
Black creek	"	" "	" 29	
Wagner creek	Polkton	A. S. Ainsworth	" 29	3,000
Whipple creek	Georgetown	Hiram Haight	" 29	6,000
Big creek	Jamestown and Georgetown	Geo. F. Richardson	" 29	9,000
Garrett's creek	Jamestown	" "	" 29	
Otsego:				
Stacey creek	Corwith	D. H. Fitzhugh	" 22	
E. br. of Sturgeon river	"	" "	" 22	20,000
W. " " "	" and Otsego	" "	" 22	

Brook trout plants, 1892.—CONTINUED.

County and name of waters.	Town.	Depositor.	Date.	Number.
Otsego—Cont'd:				
Outlet of Woodin and Berryville lakes	Corwith	Thomas C. Woodin	Mar. 22	15,000
Upper branches of Pigeon and Black rivers	" and Dover	A. C. Crane	" 22	25,000
Lake—no name	Town 29 N. R. 4 W.	Henry Stephens	" 22	
Outlet to Bradford lake	Otsego Lake	" "	" 22	25,000
Feeder to middle branch of Au Sable river	Town 29 N. R. 4 W.	" "	" 22	
Presque Isle:				
Lake Esau	Presque Isle	Wm. C. French	" 16	12,000
Roscommon:				
Dunham creek	Nestor	S. V. Thomas	" 22	6,000
St. Joseph:				
Spring run	Flowerfield	Charles Rice	" 7	12,000
Spring creek	"	Charles N. Pratt	" 7	12,000
Rocky river	"	" "	" 7	
Spring creek	Nottawa and Colon	L. A. Clapp	" 7	10,000
Trib. to Spring creek	"	George Keeck	" 7	10,000
Tuscola:				
Montague creek	Indian Fields	F. S. Wheat	" 2	
Goodwin creek	Millington and		" 2	10 000
	Watertown	" "	" 2	
Butternut creek	Indian Fields	J. H. Howell	" 2	
Sucker creek	"	" "	" 2	12,000
White creek	"	" "	" 2	
Van Buren:				
Maple creek and branches	Bangor & Arlington	Wm. Brodwell, jr.	" 7	15,000
Butternut creek	Genoa	John C. Merson	" 7	
Cedar creek	"	" "	" 7	15,000
Mill creek	"	" "	" 7	
Washtenaw:				
Casey creek	Superior and Ypsilanti	H. J. Knapp	" 7	10,000
Stony creek	Augusta	F. H. Barnum	" 7	10,000
Wayne:				
Willow run	Van Buren	J. B. Gowdry	May 7	10,000
Farmington brook	Livonia	L. Walker	Mar. 2	12,000
Wexford:				
Fairchild's creek	Cherry Grove	D. F. Diggins	Feb. 25	16,000
North branch of Pine river	" "	" "	" 25	
Slagal creek	Boon	B. W. Cooley	" 25	6,000
Potts' creek	24 N. 9 W.	Samuel D. Mills	April 4	6,000
Downing creek	South Branch and Henderson	Chittenden, Herrick & Co.	Feb. 25	
Hoxey creek	South Branch and Henderson	Chittenden, Herrick & Co.	" 25	16,000
North branch of Pine river	Hobart	G. R. & I. R. R. agent	Mar. 28	15,000
Tribs. to Manistee river	Manton	" "	" 28	25,000
Total				2,252,000

Brook trout plants, 1892, from Sault Ste Marie station.

County and name of waters.	Town.	Depositor.	Date.	Number.
Alger:				
Rock river	Au Train	Horatio Seymour	May 9	30,000
Laughing Fish creek	Onoto	" "	" 9	6,000
Baraga:				
Slate river	Avon	Charles M. Turner	" 9	6,000
Chippewa:				
Sault Ste Marie river	Sault Ste Marie	Cace Robotham	" 12	23,000
" " " "	" " "	Mich. Fish Com.	" 12	41,000
Brown's creek	" " "	George Brown	" 12	4,000
Houghton:				
Sweed Town creek	Hancock	Geo. H. Miles	" 9	6,000
Otter creek	"	" "	" 9	6,000
Pilgrim creek	"	" "	" 9	6,000
Elm creek	Adams	James H. Blandy	" 9	6,000
Salmon Trout creek	"	" "	" 9	6,000
Marquette:				
Chocolay creek	Chocolay	Horatio Seymour	" 9	6,000
Dead river	Marquette	" "	" 9	6,000
Huron creek	Ishpeming and Ely	Geo. A. Newett	" 9	6,000
Green creek	Town 47	" "	" 9	6,000
Gold creek	Tilden	" "	" 9	6,000
Total				170,000

Brown trout plants, 1891.

County and name of waters.	Town.	Depositor.	Date.	Number.
Alcona:				
Block House creek	Potts	J. W. Morin	Mar. 26	9,000
Alpena:				
Spring lake and creek	Alpena	Jas. R. Conway	" 26	15,000
Charlevoix:				
Hoffman or Branch lake	Hudson	Timothy Carter	April 17	10,000
Chippewa:				
Little and Big Rapids	Sault Ste. Marie	C. Robotham		12,000
Crawford:				
Au Sable and E. br. of Au Sable	Frederick	Elijah Flagg	April 8	10,000
Au Sable river	Grayling	D. H. Fitzhugh	" 17	15,000
Mecosta:				
Buckhorn creek	Green	Mich. Fish Com.	" 13	10,000
Honey creek	"	" " "	" 18	10,000
Cat creek and tribs.	"	" " "	" 22	20,000
Otsego:				
Outlet to Bradford lake	Waters	Stephens Lumber Co.	" 17	10,000
Branch of Au Sable river	"	Henry Stephens	" 17	10,000
Presque Isle:				
Lake Esau	Presque Isle	Wm. A. French	Mar. 26	15,000
Roscommon:				
Robinson creek	Higgins	H. A. Woodruff	April 17	10,000
Total				156,000

Brown trout plants, 1892.

County and name of waters.	Town.	Depositor.	Date.	Number.
Crawford:				
Au Sable river	Grayling	D. H. Fitzhugh	Mar. 16	25,000
Lake:				
Baldwin creek	Baldwin	W. F. Potter	April 11	20,000
Mason:				
Great Sable river	Bachelor	" "	" 11	40,000
Mecosta:				
Buckhorn creek	Green	Mich. Fish Com.	Mar. 1	10,000
S. br. of Pere Marquette river	"	" " "	April 1	31,500
Ogemaw:				
Headwaters of south branch of Au Sable river	Goodar	J. O'Connor	Mar. 22	15,000
Osceola:				
Trib. to Muskegon river	Hersey and Evart	Mich. Fish Com.	" 4	40,000
Hersey creek	Lincoln	" " "	" 16	30,000
Oscoda:				
Buckhorn creek	Potts	J. Sullivan	" 16	10,000
E. and W. branches of Big creek	Atherton	S. Gorton	" 22	25,000
Big creek	"	"	" 22	
Otsego:				
Feeder to middle branch of Au Sable river	29 N. 4 W.	Henry Stephens	" 22	25,000
Total				271,500

Lake trout plants, 1892, from Sault Ste Marie station.

County.	Name of waters.	Date.	Number.
Marquette	Sawyer lake	May 12	30,000
Ontonagon	Lake Gogebic	" 12	60,000
Chippewa	Lake Huron	" 12	114,000
Total			204,000

Plants of wall-eyed pike, 1891.

County.	Name of waters.	To whom delivered.	Date.	Number.
Antrim	Lac La Belle lake Five lakes	H. T. Cook	May 12	225,000
Bay	Saginaw bay	Mich. Fish Com.	" 25	5,535,000
Barry	Sugar Bush lake	Walter Burling	" 14	135,000
	Thornapple lake	L. P. Cole	" 25	225,000
	Lake Odessa	A. B. Belding	" 22	225,000
Benzie	Horse Shoe lake Ayers lake Pearl lake	Melville S. Pratt	" 12	100,000
Calhoun	Keslar lake	F. F. Hoaglin	" 18	225,000
	Mineral Spring lake	Chas. R. Harris	" 18	180,000
Cass	Cook's lake Indian lake	E. Barlow Jewell	" 18	225,000
	Bair lake Driskel lake	E. H. Jones	" 19	225,000
	Diamond lake	Jas. M. Shepard	" 19	225,000
	Indian lake	E. Pardee	" 18	180,000
	Baldwin lake	W. B. Dibble	" 19	225,000
	Pleasant lake	Edwin Case	" 19	180,000
	Eagle lake	B. F. Parsons	" 19	180,000
Cheboygan	Mullet lake	H. H. Pike	" 12	450,000
	Loon lake Twin lake Fish lake Silver lake	James A. Barry	" 12	225,000
Clinton	Ford lake	T. W. Curtis	" 14	135,000
Genesee	McCormick lake Begel lake	Z. B. House	" 25	270,000
	Lobdell lake	Wm. H. Johnson	" 14	135,000
	Argentine mill pond and lake	G. G. Sutherland	" 14	135,000
Gladwin	Name not given	F. L. Prindle	" 25	450,000
Grand Traverse	Clear lake	Samuel D. Mills	" 12	180,000
	Fife lake	James Monteith	" 12	225,000
Ingham	Mud lake	Mahlon H. Bray	" 12	135,000
	Pine lake	Jason E. Nichols	" 12	225,000
Isabella	La Strange lake	A. W. Hurst	" 22	225,000
Jackson	Farwell lake	G. T. Greenshaw	" 19	180,000
	Swains lake	W. H. Spratt	" 19	180,000
	Swains lake	Frank McKenzie	" 19	135,000
	Cranberry lake Batteese lake White lake Pleasant lake Brill's lake	George E. Beebe	" 25	225,000
	Grass lake	C. W. Akin	" 18	180,000
Kalamazoo	Rawson's lake Howard lake	Thomas Hewitt	" 19	180,000
	Wells' lake	Charles L. Bolles	" 19	180,000
	Sugar Loaf lake	A. M. Fellows	" 19	180,000
	Gourd Neck lake	John E. Pabst	" 19	135,000
	Gourd Neck lake	A. L. Lakey	" 18	225,000
	Sherman lake	W. S. Kirby	" 18	225,000
	Sugar Loaf lake	John S. Harrison	" 19	180,000
Kent	Scalley lake	E. J. Mosher	" 14	225,000
	Carp lake	K. Leentvaar	" 22	225,000
	Silver lake	Neal McMillan	" 22	225,000
Kalkaska	Island lake	W. G. Grovenger	" 12	180,000
Lake	Crooked lake	James Armstrong	" 25	405,000

Plants of wall-eyed pike—CONTINUED.

County.	Name of waters.	To whom delivered.	Date.	Number.
Lenawee	Turtle lake Ziegler lake Mumford lake	Melville S. Pratt	May 12	100,000
	Devil's lake	J. B. Allen	" 19	225,000
Lapeer	Big Fish lake	Peter Wallrath	" 14	135,000
Livingston	Pleasant lake	George G. Winans	" 21	565,000
	Strawberry lake	John F. Lawrence	" 21	450,000
	Crooked lake Clark's lake Pickerel lake Round lake Silver lake Oar lake	Charles E. Cushing	" 12	225,000
	Long lake	J. W. Lawson	" 12	900,000
	Island lake Pickerel lake No. 2 Briggs lake	F. G. Russell	" 12	135,000
	Zukey lake	Jacob Seabolt	" 21	225,000
	Zukey lake	Charles E. Hiscock	" 21	360,000
	Myers lake McLain lake	J. E. Martenis	" 21	450,000
Macomb	Cusic lake Nowlin lake	R. B. Owen	" 25	155,000
Mason	Lincoln lake Pere Marquette lake	A. W. Graham	" 25	450,000
Mecosta	Brady lake	Wellington Jones	" 12	180,000
	Clear lake	W. J. Sloss	" 12	450,000
Missaukee	Muskrat lake	Frank E. Cornwell	" 12	225,000
Montcalm	Baldwin lake Burgess lake Fatal lake Chromo lake	T. I. Phelps	" 12	315,000
	Tamarack lake	A. T. Call	" 12	135,000
Muskegon	Big Blue lake Duck lake Crystal lake	E. M. Ruggles	" 14	180,000
Newaygo	Big Brooks lake Little Brooks lake	W. H. Kritzer	" 22	225,000
	Big Brooks lake	Will Courtright	" 22	225,000
	Pickerel lake Two Marl lakes Kimball lake	E. J. Hewes	" 22	225,000
	Little Marl lake Big Marl lake	S. D. Bowman	" 22	225,000
Oakland	Mace Day lake	Charles Burton	" 14	135,000
	Three Mile lake	John S. Gray	" 14	180,000
	Orion lake	C. Henri Leonard	" 14	135,000
	Stony lake	E. R. Clark	" 14	225,000
	Wing lake	E. C. Poppleton	" 14	180,000
	Cooley lake	Sloan Cooley	" 14	180,000
	Lakeville lake	Geo. A. Nettleton	" 14	225,000
	Elizabeth lake	E. W. Abbott	" 14	225,000
	Cranberry lake	R. B. Owen	" 14	70,000
Oceana	School Section lake	L. N. Keating	" 14	405,000
Osceola	Wright lake Big lake Mud lake Rattail lake Briggs lake Hicks lake	J. J. Reik	" 25	225,000
Otsego	Porcupine lake	John H. Green	" 12	450,000
	Otsego lake	A. B. C. Comstock	" 12	405,000
Ottawa	Finnery lake	Lawrence H. Goodale	" 22	225,000

Plants of wall-eyed pike—CONTINUED.

County.	Name of waters.	To whom delivered.	Date.	Number.
St. Joseph	Demijohn lake	George Keech	May 19	180,000
	Little lake	Charles Butler	" 19	180,000
	Clear lake Fishers lake Pleasant lake	Charles N. Pratt	" 19	225,000
	Gray's lake	B. H. Putnam	" 19	180,000
	Crossman lake	K. C. Gray	" 19	135,000
	Thomson lake	James S. Pearson	" 19	135,000
	Johnson lake Hog creek lake	Jay G. Wait	" 19	180,000
Van Buren	Three Mile lake Huzzy's lake	C. Engle	" 18	225,000
	Lake Cory Huzzy's lake Bankrous lake	C. F. Dey	" 18	225,000
	Gravel lake Bankrous lake	E. J. Elliget	" 18	225,000
Washtenaw	Cavanaugh lake	R. S. Armstrong	" 18	180,000
Wexford	Little Clam lake Big Clam lake	J. G. Mosser	" 17	405,000
Total				27,045,000

Plants of wall-eyed pike, 1892.

County.	Name of waters.	To whom delivered.	Date.	Number.
Allegan	Eagle lake	Charles Killefer	June 3	400,000
Barry	Crooked lake	J. C. Bennett	" 3	400,000
Benzie	Crystal lake	N. A. Parker	" 12	700,000
Cass	Spring lake	Edgar Wetherbee	" 1	200,000
	Diamond lake	B. L. Rudell	" 1	1,000,000
	" "	J. M. Shepard	" 1	1, 00,000
	Twin lake	Worden Wells	" 3	400,000
	Cooke lake Pine lake	Wm. H. Murphy	" 5	800,000
	Hemlock lake	E. S. Mack	" 5	800,000
	Fish lake	Z. M. Wade	" 5	200,000
	Eagle lake	Edward Cass	" 5	600,000
	" "	B. T. Parson	" 5	600,000
Calhoun	Kesler lake	F. F. Hoaglin	" 3	400,000
Cheboygan	Mullet lake	H. H. Pike	" 3	4,000,000
Clinton	Lake on Sec. 23	W. H. Rose	" 8	400,000
Isabella	Coldwater lake	Dan. J. Gahan	" 12	200,000
	Little Field lake Campo lake	P. C. Taylor	" 12	200,000
Ionia	Long lake	Benjamin Hall	" 8	400,000
Jackson	Round lake	Charlie Van Schoick	May 30	400,000
	Cranberry lake Batteese lake White's lake Pleasant lake Brill's lake	George E. Beebe	" 30	1,000,000
	Swain's lake	T. S. Rhodes	June 1	200,000
	" "	Frank McKenzie	" 1	200,000
Kalamazoo	Sugar loaf lake	John S. Harrison	" 5	400,000
	Gourd neck lake	John E. Pabst	" 5	800,000
	Rawson's lake	Thomas Hewitt	" 5	800,000
	Howard lake	" "	" 5	800,000
	Sugar loaf lake	A. M. Fellows	" 5	400,000
	Indian lake	N. V. Jones	" 5	800,000

Plants of wall-eyed pike, 1892.—CONTINUED.

County.	Name of waters.	To whom delivered.	Date.	Number.
Kent	Reed's lake	Mich. fish com.	May 27	960,000
	Crooked lake	Henry F. Hastings	" 27	640,000
	Long lake Wilkerson's lake	Joseph Cramer	June 8	800,000
	Round lake Crooked lake Pine island lake	L. K. Madison	" 8	1,200,000
	Wabasis lake	George L. Stevens	" 8	400,000
	Camp lake	C. C. Darling	" 10	400,000
Lenawee	Wampler's lake	M. J. Pierce	May 30	2,000,000
	Evan's lake	S. W. Demuth	" 30	200,000
	" "	H. H. Halladay	" 30	200,000
Livingston	Oar lake Bidwell lake Pickerel lake Worden lake	C. E. Cushing	June 3	4,000,000
	Brophey lake	John M. Cullen	" 8	400,000
Mason	Gun lake	C. A. Toby	" 12	200,000
Muskegon	Blue lake	C. E. Covell	" 10	400,000
	Cowden Lake	E. H. Stryker	" 8	400,000
	Long lake	Asa Pike	" 8	200,000
	Baldwin lake Burgess lake Fatal lake Chromo lake	T. I. Phelps	" 8	1,200,000
Newaygo	Fremont lake 1, 2, 3, and 4th lake	Frank Cole	" 10	1,000,000
	Fremont lake 1, 2, 3 and 4th lake	A. Gerber	" 10	1,000,000
	Hep lake Rans lake Bill's lake	S. D. Thompson	" 10	600,000
	Pickerel lake	E. J. Hewes	" 10	400,000
Oceana	Crystal lake	Fred. J. Russell	" 10	400,000
Oakland	Davis lake Big lake	F. G. Eby	May 27	1,200,000
	Cooley lake	Sloan Cooley	" 27	400,000
	Three mile lake Scott's lake	John S. Gray	" 27	800,000
	Watkin's lake	E. H. Stowell	" 25	400,000
	Orchard lake	F. D. Taylor	" 27	2,000,000
	Mace day lake	Charles Burton	" 27	800,000
	Cass lake	C. R. Freeman	" 27	400,000
	Loon lake	D. R. Shaw	" 27	400,000
St. Joseph	Demijohn lake	George Keech	June 1	200,000
St. Clair	Lake St. Clair	Mich. fish com.	May 26	6,000,000
	Corey's lake	Chas. Rice	June 1	1,000,000
	" "	C. N. Pratt	" 1	1,000,000
Van Buren	Paw Paw lake	Pierson & Baldwin	" 3	400,000
	Three mile lake	C. Engle	" 3	400,000
	Pugsley's lake	Fred. Belsborrow	" 3	400,000
	School section lake	Jeff Chaffee	" 3	400,000
	Cory lake Huzzy lake Bankrous lake	C. F. Dey	" 3	1,600,000
Wexford	Upper clam lake	Mich. fish com.	May 30	3,600,000
	Pleasant lake	E. L. Metheany	June 1	400,000
Total				57,300,000

Distribution of carp, 1891.

County.	Depositor.	Location.	Date.	Number.
Allegan	H. H. Goodrich	Ganges	Sept. 25	35
	J. A. Newman	Hoppertown	" 25	35
	Dr. C. W. Andrews	Wayland	" 22	25
Barry	John A. Bacheller	Quimby	" 25	25
	H. Houghton	"	" 25	25
Berrien	C. D. Brownell	New Buffalo	" 25	50
Calhoun	C. R. Harris	Battle Creek	" 22	100
	F. C. Courter	Albion	" 22	100
Cass	Edwin Hayward	Casnovia	" 25	25
	Fred Jones	Jones	" 25	10
	J. Fred. Merritt	Williamston	" 25	25
	Geo. W. Bows	Jones	" 25	25
	John Bickle	"	Oct. 26	24
	Daniel Ludwig	Newbury	" 26	15
Cheboygan	W. H. Merritt	Rondo	Sept. 22	50
	Frederick Lautz	Trowbridge	" 22	25
Clare	Oliver Beemer	Clare	" 29	25
Eaton	Robert Hubbard	Chester	" 25	25
	Benjamin Haight	Vermontville	" 23	35
Genesee	Wm. Tinker, Jr.	Pine Run	" 29	5
Grand Traverse	D. G. Chandler	Traverse City	" 22	50
Gratiot	George Argent	Sumner	" 29	25
Isabella	Jos. Loeberl	Sherman City	" 29	30
	Nathan J. Conrad	Russell	" 29	30
Ionia	H. Hitchcock	Lyons	" 29	25
Jackson	Harvey H. Raby	Norvell	" 22	50
	C. B. Bush	Jackson	" 22	25
Kalamazoo	Nathan Spicer	Kalamazoo	" 22	200
Kent	C. O. Smeadley	Grand Rapids	" 22	50
	A. L. Burton	Ada	" 22	50
	Neal McMillan	Rockford	" 22	125
Lapeer	Anthony Williams	Attica	" 25	25
Lenawee	J. B. Allen	Devil's Lake	" 25	25
Livingston	A. Sharp	Howell	" 29	25
Mason	C. A. Toby	Free Soil	" 29	25
Monroe	Franklin Ford	Dunn	" 26	50
Montcalm	Edward Dunn	Gowen	" 29	25
Muskegon	C. L. Gunn	Muskegon	" 25	50
Newaygo	E. O. Shaw	Newaygo	" 25	50
Oakland	O. L. Hemmingway	Ovid	" 22	50
	Thomas P. Green	Holly	" 29	10
	A. B. Coryell	Thomas	" 22	50
	J. F. Bailey	Oxford	" 22	50
Oceana	W. H. Chase	New Era	" 25	25
Osceola	W. J. McIlwain	Evart	" 29	17
Otsego	R. R. Agent	Otsego lake	" 22	100
Sanilac	J. D. Eastman	Brown City	" 29	25
Shiawassee	Jesse F. Parker	Laingsburg	" 29	25
	Marcus Wilcox	Corunna	" 29	50

Distribution of carp, 1891.—CONTINUED.

County.	Depositor.	Location.	Date.	Number.
Tuscola	J. H. Howell	Caro	Sept. 22	25
	M. O'Brien	Juniata	" 22	25
Van Buren	William Young	Grand Junction	" 25	35
	Wm. O. Cook	South Haven	" 25	35
	S. Deuel	Decatur	April 20	20
	James Enright	"	May 10	20
Washtenaw	Philip Blum	Bridgewater	Sept. 25	25
	Azro Fletcher	Ypsilanti	" 25	25
Total				2,231

Distribution of carp, 1892.

County.	Depositor.	Location.	Date.	Number.
Barry	J. M. Rogers	Hastings	Oct. 17	50
Branch	Will Coville	Union City	Sept. 27	50
Cass	Cassopolis Milling Co.	Cassopolis	" 27	50
	Edgar Wetherbee	Jones	" 27	50
	J. R. Bowers	"	" 27	50
	George Detrick	Vandalia	" 27	50
	Sylvester Grise	Summerville	Nov. 1	75
Calhoun	Zachariah Little	Burlington	Sept. 27	50
	F. C. Courter	Albion	" 28	50
	F. F. Hoaglin	"	" 28	50
Clinton	A. Schenck & Son	Elsie	Oct. 17	50
Crawford	L. Strutzenberg	Appenzell	" 25	50
Huron	John Hoytaleiviez	Parisville	" 17	50
	William D. King	Pinnebog	" 17	50
Ionia	Daniel Spire	Muir	Sept. 28	100
Kalamazoo	Fred B. Lane	Kalamazoo	" 28	50
	F. Rawson	"	" 28	50
	Joseph Hipp	Alamo	Oct. 12	50
Kent	C. B. Conger	Grand Rapids	Sept. 28	100
	Neal McMillan	Rockford	Oct. 12	50
	John Carlyle	"	" 17	50
Lenawee	L. P. Hutchinson	Addison	" 17	50
Manistee	William Knich	Manistee	Sept. 28	200
Oakland	J. Shannon	Wixom	" 28	100
	John Phillips	Milford	" 28	100
	S. Alexander	Birmingham	" 28	200
	A. R. Rood	Holly	" 28	50
St. Joseph	H. Young	Three Rivers	" 27	50
Van Buren	T. Broadhurst	Decatur	July 29	50
Wexford	John Copper	Hobart	Oct. 17	50
Total				2,025

Eel plants, 1891.

County.	Name of waters.	Depositor.	Date.	Number.
Allegan	Scott lake	J. A. Newman	July 3	5,000
	Hutchin's lake	W. H. McCormick	" 3	5,000
	No name	W. H. Whitbeck	" 3	5,000
Antrim	Sand lake	O. J. Smith	June 26	3,000
Barry	Mud lake Long lake Wolf lake	Will Carpenter	" 26	3,000
	Sugar Bush lake	Walter Burling	" 26	3,000
Branch	Goodrich lake	W. R. Mandigo	" 25	3,000
Calhoun	Nottawasepe creek	W. H. Holcomb	" 25	3,000
	No name	N. A. Osgood	" 24	3,000
Cass	Indian lake	Wm. Murphy	" 24	3,000
	Monkey run	A. B. Witherbee	" 25	3,000
Cheboygan	Crooked lake Cass lake Douglass lake	Wm. Fitzgerald	" 26	6,000
Crawford	Kile lake	L. C. Huxley	" 27	3,000
	Kile lake	M. C. R. R. Agent	" 27	3,000
Eaton	Long lake	W. L. Freemire	" 26	3,000
Genesee	Bingham creek	E. D. Smith	July 3	4,000
Gratiot	Pine run	Stephen Ostrander	" 3	5,000
	McBain lake	John E. Martenis	" 3	3,000
Hillsdale	Head of Hillsdale creek	Edward Joughin	" 3	5,000
Ionia	Turkey Creek pond Flat river	H. Bailey	" 3	11,000
Jackson	Michigan Centre ponds Vandercook's lake Brown's lake Wolf's lake Gillet's lake	Geo. E. Beebe	June 24	3,000
	Wolf lake	W. R. Hookway	" 24	3,000
	Clear lake	F. A. Showerman	" 24	3,000
	Grass lake	Geo. D. Burton	" 24	3,000
Kalamazoo	Sherman lake	H. Dale Adams	" 24	3,000
Kalkaska	Mud lake	George Ines	" 26	3,000
Kent	Round lake Skelly lake	G. O. Bignell	July 3	8,000
	No name	W. C. Bowman	June 26	3,000
	Camp lake	C. C. Darling	" 26	3,000
	Thornapple river	H. Bailey	July 3	4,000
Lapeer	Bronson lake	R. B. Conklin	" 3	5,000
	No name	John D. Brown	" 3	5,000
	No name	Clark Linabury	" 3	5,000
Livingston	Long lake	John W. Lawson	" 3	6,000
Lenawee	Raisin river	A. C. Schleman	" 3	5,000
Monroe	Huron river	John Strong	" 3	5,000
Montcalm	Rock lake	Jay Gates	" 3	4,000
	Cedar lake	Sidney Phippeny	" 3	4,000
	Gowen pond	H. Bailey	" 3	1,000
Montmorency	Crooked lake Twin lake	Allen Briley	June 27	3,000
Muskegon	Twin lakes	Albert Page	" 26	3,000
Missaukee	Muskrat lake	D. Reeder	" 26	3,000
Newaygo	Hess lake	Will H. Shrim	" 26	3,000
	Island lake	Alburtus Andrus	July 3	8,000

Eel plants, 1891.—CONTINUED.

County.	Name of waters.	Depositor.	Date.	Number.
Oakland	White lake	C. E. Everts	July 3	9,000
	Woodhull lake	John N. Walter	" 3	6,000
	Big lake	F. G. Ely	" 3	4,000
Osceola	Center lake Gogin's lake	John Carman	June 26	3,000
Otsego	Nield's lake	Ernest Pettifer	" 26	3,000
	Porcupine lake	John H. Green	" 27	3,000
	Big lake	Alfred Savage	" 27	3,000
Shiawassee	Byron mill pond Kanouse lake	John E. Martenis	July 3	5,000
	Shiawassee river Corunna mill pond	Roll E. Kelsey	" 3	8,000
St. Clair	Pine river and tributaries	John Huber	" 3	6,000
St. Joseph	St. Joseph river	Charles Rice	June 25	3,000
Tuscola	Clark's lake	Lewis Lanway	July 3	5,000
	Cass river	P. L. Varnum	" 3	5,000
Van Buren	Lamphere pond	L. D. Harrison	June 24	3,000
	Lake Cory Huzzy lake Bankrous lake	C. F. Dey	" 24	3,000
	No name	Parsons & Baldwin	July 3	5,000
Washtenaw	Cavanaugh lake	E. L. Negus	June 24	3,000
	Cavanaugh lake	R. J. West	" 24	3,000
	Lumford lake Fork pond Slue lake	E. R. Aldrich	July 3	12,000
Wexford	Clam lake	Enos Clark	June 26	3,000
Total				273,000

White bass plants, 1891.

County.	Name of waters.	Depositor.	Date.	Number.
Calhoun	Goguac lake	Michigan Fish Com.	June 9	300,000
	Gourd Neck lake	" "	" 9	500,000
Livingston	Clear lake	" "	" 9	300,000
Oakland	Orchard lake	" "	" 9	500,000
	Black Walnut lake	" "	" 9	600,000
Van Buren	Gravel lake	" "	" 9	300,000
Total				2,500,000

Total plants of brook trout in fourteen years.

1879	12,000	1886	719,000
1880	50,400	1887	1,090,000
1881	388,500	1888	1,639,000
1882	251,000	1889	2,468,000
1883	219,000	1890	2,578,000
1884	353,000	1891	2,500,000
1885	408,000	1892	2,422,000
Total			15,097,900

The above is a statement of the plants of brook trout made from the Paris station from and including 1879, the year in which the trout work of the commission was removed from Pokagon to Paris.

Total plants of whitefish.

1874	1,532,000	1884	37,750,000
1875	2,211,500	1885	40,000,000
1876	9,310,000	1886	61,620,000
1877	8,001,000	1887	72,984,000
1878	12,520,000	1888	72,968,000
1879	14,545,000	1889	63,000,000
1880	10,695,000	1890	109,700,000
1881	3,000,000	1891	104,000,000
1882	18,170,000	1892 from Detroit station	65,500,000
1883	23,785,000	1892 from Sault Ste. Marie station	9,724,000
Total			740,965,500

Total plants of wall-eyed pike.

1882	1,120,000	1889	44,340,000
1884	2,040,000	1890	22,300,000
1886	1,806,256	1891	27,045,000
1887	3,280,000	1892	57,300,000
1888	11,492,000		
Total			170,723,256

Total plants of carp.

1881	1,093	1889	3,490
1885	2,088	1890	5,798
1886	3,422	1891	2,231
1887	2,843	1892	2,025
1888	3,878		
Total			26,868

Total plants of Atlantic salmon.

1873	21,350	1874	139,000
Total			160,350

Total plants of California trout (fry).

1880	12,000	1889	4 000
1884	6,000	1890	16,000
1885	25,000	1890 (adults)	475
1887	20,000		
Total			83,475

Total plants of Swiss lake trout.

1890	17,360

Total plants of Loch Leven trout.

1885	8,000	1890	30,000
1888	5,000		
Total			43,000

Total plants of brown trout.

1889	20,000	1891	156,000
1890	60,000	1892	271,500
Total			507,500

Total plants of lake trout.

1875	150,000	1885	215,000
1877	168,500	1886	490,000
1878	433,834	1889 (two years old)	13,000
1879	379,000	1890 " " "	467
1880	26,500	1892 (from Sault Ste. Marie station)	204,000
Total			2,080,301

Total plants of California salmon.

1873	45,900	1878	73,000
1874	419,930	1879	215,246
1875	323,000	1880 (adults)	575
1876	227,000		
Total			1,304,651

Total plants of Schoodic salmon.

1876	20,300	1885	48,000
1878	26,000	1886	23,000
1879	4,867	1887	23,636
1880	20,000	1888	73,424
1882	13,517	1889	5,000
1883	27,874	1890	44,000
Total			329,618

Total plants of eels.

1877	265,000	1883	236,000
1878	405,000	1885	325,000
1879	317,000	1891	273,000
1881	390,000		
Total			2,211,000

Total plants of black bass.

1880	3,500	1888	1,560
1881	7,000	1890	185
Total			12,245

Total plants of white bass.

1891	2,500,000

TEMPERATURE OF WATER.

DETROIT STATION.

Temperature of water during whitefish hatching season from Nov. 6, 1890, to April 30, 1891.

1890.		1891.	
Nov. 6-7	47°	Jan. 22	34°
8-9	46	23-29	35
10-14	47	30-31	36
15-22	46	Feb. 1	36
23-25	45	2-28	35
26-27	44	Mar. 1-11	35
28-29	43	12	36
30	42	13	36
Dec. 1	41	14-22	35
2	40	23-26	36
3	38	24	37
4-7	37	April 1-2	38
8-9	36	3	39
10-13	35	4-7	38
14-15	34	8	39
16-17	35	9	40
18-26	36	10-11	41
27-29	35	12-13	42
30-31	36	14-15	43
		16-17	44
1891.			
Jan. 1-5	36	18	45
6-7	37	19	46
8-9	34	20	47
10-12	35	21	48
13-16	34	22-30	49
17-21	35		

DETROIT STATION.

Temperature of water during whitefish hatching season from November 6, 1891, to April 23, 1892:

1891.		
Nov.	6-10	46°
	11-18	47
	19-22	45
	23-26	42
	26-30	40
Dec.	1	38
	2-3	39
	4-5	38
	6	39
	7	38
	8-10	37
	11-13	38
	14-15	39
	16	40
	17	39
	18-21	37
	22-33	38
	24-25	39
	26-30	38
	31	37
1892.		
Jan.	1	37
	2	38
	3	37
	4-10	36
	11-19	35
	20-24	34
	25	35

1892.		
Jan.	26-28	34°
	29-31	35
Feb.	1-3	35
	4-16	34
	17-29	35
Mar.	1-5	35
	6	34
	7-13	35
	14-16	34
	17-21	35
	22	34
	23-25	35
	26	36
	27	37
	28-29	38
	30-31	39
Apr.	1	39
	2-3	42
	4	43
	5	44
	6-8	45
	9-10	44
	11	43
	12-13	42
	14-15	43
	16-17	42
	18-20	43
	21-23	44

SAULT STE. MARIE STATION.

Temperature of water during trout and whitefish hatching season from October 20, 1891, to May 16, 1892.

1891.		
Oct.	20-31	42°
Nov.	1-17	42
	18	41
	19	40
	20	41
	21	42
	22-23	43
	24	42
	25-26	40
	27	39
	28-30	38
Dec.	1-3	40
	4	41
	5	40
	6-9	38
	10-12	39
	13-15	38
	16	37
	17	35
	18-19	34
	20-21	36
	22-24	37
	25	38
	26	37
	27	36
	28	34
	29	36
	30	33

1891.		
Dec.	31	34°
1892.		
Jan.	1	36
	2	35
	3-31	34
Feb.	1-12	34
	13	33
	14-29	34
Mar.	1-31	34
April	1-14	34
	15-20	35
	21-22	36
	23	37
	24	36
	25-26	35
	27-28	36
	29	35
	30	34
May	1	34
	2	35
	3-4	36
	5	37
	6	38
	7	37
	8	38
	9	39
	10-16	40

PARIS STATION.

Temperature of water during trout hatching season, from Sept. 29, 1890, to May 12, 1891.

1890.		
Sept.	29	42°
	30	44
Oct.	1	44
	2-3	46
	4	45
	5	46
	6	44
	7-16	46
	17	44
	18	42
	19	44
	20	46
	21-24	44
	25-26	46
	27	45
	28-29	46
	30	44
	31	45
Nov.	1-2	46
	3-4	45
	5	46
	6	45
	7	46
	8-10	44
	11-13	45
	14-15	46
	16	45
	17-18	46
	19-20	44
	21	46
	22	45
	23-25	44
	26-27	46
	28	45
	29-30	44
Dec.	1	45
	2	44
	3-4	42
	5	41
	6-8	40
	9-10	42
	11	44
	12	42
	13-14	41
	15-16	40
	17	41
	18-19	40
	20	38
	21	39
	22	40
	23-25	38
	26	39
	27	38
	28-29	40
	30-31	38
1892.		
Jan.	1	38
	2-3	36
	4	38
	5	40
	6	38
	7-9	36
	10	39
	11	38
	12-14	40
	15	38
	16	36
	17-20	40
	21	38
	22-24	40
1892.		
Jan.	25	39°
	26	42
	27-28	40
	29	41
	30-31	42
Feb.	1-2	40
	3	36
	4	35
	5	36
	6	38
	7-9	40
	10-12	38
	13	40
	14-15	38
	16	36
	17-20	40
	21	38
	22-24	40
	25	39
	26	42
	27-28	40
Mar.	1-3	38
	4	39
	5	40
	6	39
	7-9	40
	10	38
	11	40
	12	42
	13-14	40
	15-16	38
	17-18	39
	19	38
	20-21	40
	22	41
	23	39
	24	38
	25	39
	26	38
	27-28	40
	29	39
	30	40
	31	38
April	1	39
	2-3	40
	4	41
	5	42
	6	40
	7	41
	8-10	42
	11	43
	12-13	44
	14	42
	15	41
	16	42
	17-19	44
	20-21	43
	22-23	44
	24-25	43
	26-27	44
	28-29	43
	30	44
May	1-2	42
	3-4	43
	5-6	44
	7	45
	8-9	43
	10-11	44
	12	43

PARIS STATION.

Temperature of water during trout hatching season from Sept. 26, 1891, to April 28, 1892.

1891.		
Sept.	26	51°
	27	50
	28–29	51
	30	49
Oct.	1–2	50
	2–7	48
	8–11	49
	12	50
	15	51
	16	50
	17	52
	18	51
	19–20	50
	21–22	49
	23–26	48
	27–28	47
	29	48
	30–31	47
Nov.	1	47
	2–3	46
	4–5	47
	6–7	48
	8–9	47
	10–13	46
	14	45
	15–16	46
	17–20	44
	21	45
	22	46
	23	45
	24–25	44
	26	45
	27	42
	28–30	40
Dec.	1	45
	2–4	46
	5	41
	6–7	42
	8–9	40
	10–11	42
	12	44
	13	45
	14	46
	15–16	40
	17	41
	18–19	40
	20	38
	21	39
	22	40
	23–25	38
	26	39
	27	38
	28–29	40
	30–31	38
1892.		
Jan.	1	38
	2–3	36
	4	38
	5	40
	6	38
	7–9	36
	10	39
	11	38
	12–14	40
	15–17	38
1892.		
Jan.	18–20	37
	21–23	36
	24	37
	25	38
	26	37
	27–28	36
	29–30	37
	31	38
Feb.	1	38
	2	39
	3–4	40
	5–7	38
	8	39
	9	38
	10–11	39
	12–14	38
	15	39
	16	38
	17–18	40
	19–20	42
	21–23	43
	24–26	40
	27	38
	28–29	40
Mar.	1	38
	2	37
	3	40
	4–5	42
	6	40
	7	39
	8	42
	9	40
	10	36
	11	38
	12	40
	13	38
	14–16	36
	17–18	37
	19	38
	20	37
	21–22	36
	23–28	40
	29	39
	30	41
	31	42
April	1	42
	2	45
	3	42
	4	44
	5	46
	6	44
	7–8	42
	9	38
	10	40
	11–13	38
	14–15	40
	16–17	41
	18–20	40
	21	43
	22–23	42
	24	39
	25–26	40
	27	44
	28	48

INSURANCE.

DETROIT STATION.

On hatching house	$4,000 00	
On automatic jars	1,600 00	
		$5,600 00

PARIS STATION.

On new hatching house	$3,000 00	
On old hatching house	300 00	
On superintendent's residence	1,000 00	
On superintendent's barn	100 00	
On wagons, harness, etc.	50 00	
On overseer's residence	400 00	
On trays, troughs, etc., in new hatching house	350 00	
On trays, troughs, etc., in old hatching house	200 00	
On camp outfits	300 00	
On office and shop	200 00	
On office furniture and fixtures and tools in shop	100 00	
On car house	125 00	
		$6,125 00

INVENTORY.

PARIS STATION.

158 acres of land with overseer's dwelling and meander of Cheney creek		$4,000 00
Superintendent's house	$1,400 00	
Barn	315 00	
Ice house	28 00	
Shop and office	100 00	
Old hatchery	600 00	
New hatchery	4,000 00	
Car house	200 00	
Apparatus, tools and camp outfit	1,801 93	
Pump logs	238 50	
Windmill, tank and connections	542 00	
Ponds, races and other repairs to ponds	4,200 00	
Office furniture and books	43 30	
		13,468 73
		$17,468 73
Car for transporting fish	$3,550 00	
Outfit, curtains, lamps, stoves, bedding, etc.	194 80	
		3,744 80

DETROIT STATION.

Buldings	$6,375 00
Chase automatic jars	2,000 00
Storage tanks and connections	2,500 00
Steam boiler, pump and connections	850 00
Apparatus, tools, furniture, fishing outfits, etc.	2,711 62
Total	$14,436 62

SAULT STE. MARIE STATION.

Whitefish tanks and connections	$200 00
Trout tanks and connections	75 00
Chase automatic jars, complete	471 60
Fish and egg trays	100 00
Tools and furniture	138 50
Total	$985 10

Fishing outfit at Torch lake	$420 48

GLENWOOD STATION.

Fish house, tanks and fixtures	$175 00
Fish cans	90 00
Wire screens, nets and tools	11 75
Total	$276 75

SECRETARY'S OFFICE.

Furniture	$294 90
Library	48 50
Record books and stationery	87 00
Total	$430 40

RECAPITULATION.

Paris station	$17,468 73
Car	3,744 80
Detroit station	14,436 62
Sault Ste. Marie station	985 10
Fishing outfit at Torch lake	420 48
Glenwood station	276 75
Secretary's office	430 40
Total	$37,762 88

TREASURER'S REPORT.

Report of Wm. A. Butler, jr., treasurer Michigan Fish Commission.

1890.			
Oct. 1	Cash on hand	$676 30	
	From State Treasurer	5,638 13	
	From other sources	1,296 88	
	Vouchers paid		$7,530 81
Dec. 31	Balance		80 50
		$7,611 31	$7,611 31
1891.			
Jan. 1	Cash on hand	$80 50	
	From State Treasurer	5,638 12	
	From other sources	30 66	
	Vouchers paid		$4,928 41
Mar. 31	Balance		820 87
		$5,749 28	$5,749 28
Apr. 1	Cash on hand	$820 87	
	From State Treasurer	5,638 12	
	Vouchers paid		$6,449 66
June 30	Balance		9 33
		$6,458 99	$6,458 99
July 1	Cash on hand	$9 33	
	From State Treasurer	6,870 75	
	From other sources	350 00	
	Vouchers paid		$7,649 14
Sept. 30	Balance overdrawn	419 06	
		$7,649 14	$7,649 14
Oct. 1	Balance overdrawn		$419 06
	From State Treasurer	$6,870 75	
	From other sources	1,975 34	
	Vouchers paid		8,017 16
Dec. 31	Balance		409 87
		$8,846 09	$8,846 09
1892.			
Jan. 1	Cash on hand	$409 87	
	From State Treasurer	6,870 75	
	Vouchers paid		$5,541 68
Mar. 31	Balance		1,738 94
		$7,280 62	$7,280 62
Apr. 1	Cash on hand	$1,738 94	
	From State Treasurer	6,870 75	
	From other sources	42 39	
	Vouchers paid		$7,467 77
June 30	Balance		1,184 31
		$8,652 08	$8,652 08
July 1	Cash on hand	$1,184 31	
	From State Treasurer	6,870 75	
	From other sources	16 00	
	Vouchers paid		$5,050 37
Sept. 30	Balance		3,020 69
		$8,071 06	$8,071 06

Treasurer's report.—CONTINUED.

	Special account.		
1890.			
Oct. 1	Cash on hand	$605 46	
	From Wallich	392 00	
	Vouchers paid		$791 41
Dec. 31	Balance		206 05
		$997 46	$997 46
1891.			
Jan. 1	Cash on hand	$206 05	
1892.			
Jan. 1	Cash on hand	206 05	
Apr. 1	Cash on hand	206 05	
July 1	Cash on hand	206 05	
	Vouchers paid		$206 05
Sept. 30	Account closed.		

LIST OF FISH COMMISSIONERS.

A list of the names, addresses, and termination of appointments of the Fish Commissioners of the various states and territories of the United States.

ALABAMA.

(First commissioners appointed in 1871.)

Has no comm issioners.

ARIZONA.

(First commissioners appointed in April, 1881.)

W. J. Hill, Belmont	(1)
Ed. Schwartz, Phœnix	(1)
T. W. Otis, Prescott	(1)

ARKANSAS.

(First commissioners appointed January 25, 1876.)

Has no commissioners.

CALIFORNIA.

(First commissioners appointed April 25, 1870.)

Joseph D. Redding, 37 Chronicle building, San Francisco, president	(1)
H. L. McNeil, Los Angeles, secretary	(1)
William C. Murdoch, San Francisco, treasurer	(1)

COLORADO.

(First commissioner appointed February 9, 1877.)

No return.

CONNECTICUT.

(First appointed September 11, 1866.)

R. B. Chalker, Saybrook	June 20, 1893
James A. Bill, Lyme	August 26, 1893
William S. Downs, Birmingham	July 1, 1894

Commissioners of shell-fisheries.

(Commission authorized April 14, 1881.)

W. M. Hudson, Hartford	July 1, 1893
George C. Waldo, Bridgeport	July 1, 1895
Charles W. Beardsley, Milford	July 1, 1895
Frederick Botsford, New Haven, clerk.	

(1) Holds office at pleasure of governor.

DELAWARE.

(First commissioner appointed April 23, 1881.)

James Milligan, Delaware City .... August 13, 1896

FLORIDA.

(First commissioner appointed ———.)

J. H. Smith, Titusville .... April, 1893
L. H. Sellars, Pensacola .... April, 1893
M. Moseley, Palatka .... July 15, 1895

GEORGIA.

(Commissioner of agriculture made *ex officio* fish commissioner, 1876.)

Dr. H. H. Cary, La Grange 1894
Hon. R. T. Nesbitt, Atlanta 1894

IDAHO.

Has no commissioners.

ILLINOIS.

(First commissioners appointed May 20, 1875.)

N. K. Fairbank, Chicago, president .... July 1, 1894
S. P. Bartlett, Quincy, secretary .... July 1, 1893
George Brenning, Centralia .... July 1, 1895

INDIANA.

(First commissioner appointed September, 1881.)

*W. T. Dennis, Richmond .... (1)

IOWA.

(First commissioner appointed March 30, 1874.)

T. J. Griggs, Spirit Lake .... April 1, 1894

KANSAS.

(First commissioner appointed March 10, 1877.)

J. B. Mason, Eureka .... April 4, 1893

KENTUCKY.

(First commissioners appointed March 22, 1876.)

Has no commissioner.

LOUISIANA.

No return.

MAINE.

Commissioners of fisheries and game.

(First commissioners appointed January 1, 1867.)

†E. M. Stilwell, Bangor .... December 31, 1894
H. O. Stanley, Dixfield .... December 31, 1895

Commissioner of sea and shore fisheries.

E. W. Gould, Searsport .... April 14, 1894

(1) Pleasure of governor.
* Resigned January 10, 1893.
†Died January 15, 1893.

MARYLAND.

(First commissioners appointed in April, 1874.)

Richard T. Browning, Oakland	March 2, 1894
John S. Sudler, Manokin	March 2, 1894

MASSACHUSETTS.

Commissioners of inland fisheries and game.

(First commissioners appointed May 3, 1865.)

Edward K. Lathrop, Springfield	June 30, 1894
Edward A. Brackett, Winchester	October 9, 1894
Isaiah C. Young, Wellfleet	October 23, 1894

MICHIGAN.

(First commissioners appointed April 25, 1873.)

Joel C. Parker, Grand Rapids	January 1, 1893
Hoyt Post, Detroit	January 1, 1895
Herschel Whitaker, Detroit	January 1, 1897

Officers—W. D. Marks, Detroit, superintendent.
George D. Mussey, Detroit, secretary.
William A. Butler, Jr., Detroit, treasurer.

MINNESOTA.

(First commissioners appointed in May, 1874.)

No return.

MISSISSIPPI.

No return.

MISSOURI.

(First commissioners appointed August 2, 1877.)

H. M. Garlichs, St. Joseph	January 20, 1893
Jackson L. Smith, Kansas City	January 20, 1893
Edward Cunningham, Jr., St. Louis	January 20, 1893

MONTANA.

Has no commission.

NEBRASKA.

(First commissioners appointed June 2, 1879.)

No return.

NEVADA.

(First commissioners appointed in 1877.)

George T. Mills, Carson City	(1)

NEW HAMPSHIRE.

(First commissioners appointed August 30, 1866.)

E. B. Hodge, Plymouth	June 1, 1893
Willard H. Griffin, Henniker	June 23, 1893
Nathaniel Wentworth, Hudson	December 2, 1897

(1) Term of office four years.

NEW JERSEY.

(First commissioners appointed March 29, 1870.)

Commissioners of fish and game.

George Pfeiffer, Jr., Camden, chairman	1896
R. D. Foote, Morristown, secretary	1897
Parker W. Page, Summit	1895
Thomas Maskell, Morristown, fish and game protector	

NEW MEXICO.

Has no fish commission as such. The legislative act approved February 14, 1889, entitled "An act to provide for the protection and propagation of fish," provides that the governor shall "appoint fish wardens in each county of this territory who shall hold their office during the pleasure of the governor." Under this act 44 wardens have been appointed.

NEW YORK.

(First commissioners appointed April 22, 1868.)

L. D. Huntington, New York, President.
Edward P. Doyle, New York, Secretary.
W. H. Bowman, Rochester.
A. Sylvester Joline, Tottenville.
D. G. Hackney, Fort Plain.
Robert Hamilton, Greenwich.

NORTH CAROLINA.

(First superintendent of fisheries appointed April 2, 1877.)

No return.

NORTH DAKOTA.

Has no commission.

OHIO.

(First commissioners appointed April 1, 1879.)

C. V. Osborne, Dayton, President.
James A. Henshall, Cincinnati, Secretary.
E. D. Potter, Toledo.
J. H. Newton, Newark.
Wm. R. Huntington, Cleveland.

OKLAHOMA.

No return.

OREGON.

(First commissioners appointed April 1, 1879.)

R. C. Campbell, Rainier	March, 1893
F. C. Reed, Astoria, president	March, 1893
George T. Myers, Portland	March, 1893

PENNSYLVANIA.

(First commissioners appointed April 15, 1866.)

H. C. Ford, Philadelphia, president	June 1, 1893
H. C. Demuth, Lancaster, secretary	June 1, 1893
George H. Welshons, Pittsburg, corresponding secretary	June 1, 1893
W. L. Powell, Harrisburg, treasurer	June 1, 1893
S. B. Stillwell, Scranton	June 1, 1893
Louis Streuber, Erie	June 1, 1893

RHODE ISLAND.

(First commissioners appointed in 1868.)

Commissioners of inland fisheries.

Henry T. Root, Providence	June 20, 1895
William P. Morton, Olneyville	June 20, 1895
J. M. K. Southwick, Newport	June 17, 1895

Commissioners of shell-fisheries.

James C. Collins, Providence, commissioner and secretary	April 22, 1894
James M. Wright, Foster Centre, Asst. commissioner	April 22, 1894
George C. Cross, Charlestown, Asst. commissioner	April 22, 1894

SOUTH CAROLINA.

(First superintendent of fisheries appointed December 23, 1878.)

No return.

SOUTH DAKOTA.

Has no commission.

TENNESSEE.

(First commissioners appointed January 14, 1877.)

No return.

TEXAS.

(First commissioner appointed September 26, 1879.)

Has no commission.

UTAH.

(Action regarding fish culture dates from 1871.)

No return.

VERMONT.

(First commissioners appointed in 1865.)

John W. Titcomb, Rutland	fall 1896
C. C. Warren, Waterbury	fall 1896

VIRGINIA.

(First commissioner appointed in April, 1874.)

John T. Wilkins, Bridgetown	January 1, 1893

WASHINGTON.

(First commissioner appointed November 9, 1877.)

No return.

WEST VIRGINIA.

(First commissioners appointed June 1, 1877.)

C. S. White, Romney, president	April 17, 1894
F. J. Baxter, Sutton, treasurer	April 17, 1894
N. C. Prickett, Ravenswood, secretary	April 17, 1894

WISCONSIN.

(First commissioners appointed March 20, 1874.)

Philo Dunning, Madison, president	April 1, 1897
A. V. N. Carpenter, Milwaukee	April 1, 1897
C. L. Valentine, Jamesville, secretary and treasurer	April 1, 1893
Mark Douglas, Melrose	April 1, 1893
Calvert Spensley, Mineral Point	April 1, 1898
J. J. Hogan, La Crosse	April 1, 1898
The governor, *ex officio*.	

WYOMING.

(First commissioners appointed December 13, 1879.)

Gustave Schnitger, Laramie	(1)

(1) Pleasure of governor.